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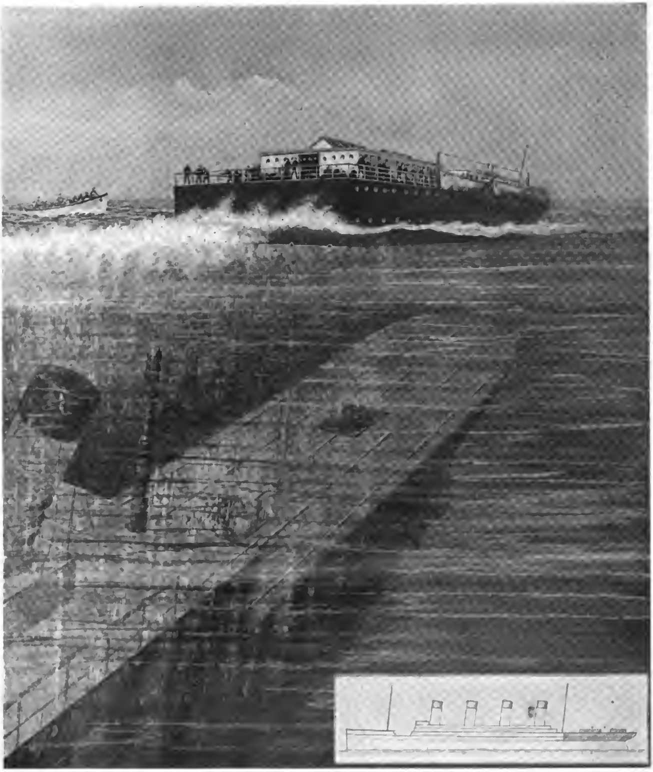


The upper decks of the after-portion of a vessel afloat after the ship of which they were a part has sunk: a suggested pontoon method of saving life at sea.

SAFETY AT SEA.—[See page 12.]

On Metallic Colloids and Their Bactericidal Properties[*]

The History of Collosols

By Henry Crookes

MAN is always fighting against unseen foes. In the mediæval ages a question was often discussed, viz., "How many angels can stand on the point of a needle?" If instead of angels we say "devils" or "microbes"—and devils are only angels of opposite polarity—the subject can be brought more clearly to our every-day comprehension. Microbes of disease are the "devils" that medical science is always warring against; they are so small as to be invisible to the naked eye, and, in fact, can only be seen under a high-power microscope—about 1,000 can be placed on the point of a very fine needle. Modern science has, in spite of their minuteness, found them, identified them, photographed, isolated, cultivated, and finally devised means of killing them. The simplest method of killing microbes is by the application of heat; sunlight has also been found to be a very efficient sterilizing agent. Various disinfectants, such as carbolic acid, chloride of lime, permanganate of potash, etc., have been proved to be deadly to microbes. Unfortunately for us human beings, nearly every efficient germicide known until recently has an irritating or destructive action on living organic tissues. The dream of the doctor has been to find an agent that will kill disease, or, in other words, bacteria, and will at the same time do no harm to the tissues of the human body. Immediately following the discovery of radium it was found that the emanations from that wonderful element had a very strong germicidal action, but almost at the same time it was noticed that a very serious burning effect on the skin and flesh was also produced.

In June, 1903, I exhibited at the Royal Society a number of plate cultures and photographs, illustrating the germicidal action of radium emanations on several forms of microbes. The radium rays undoubtedly kill the microbes, but at the same time, unless administered with the most scrupulous care, they also kill, or *burn up*, the living tissues of the body.

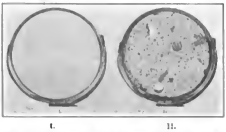
The radium emanations are due to the breaking down of the atom of radium, and electrons are constantly flying off with about two thirds the speed of light (182,000 miles per second). These electrons are now looked upon as being absolute units of negative electricity. To try and illustrate their size is difficult; imagine one drop of water magnified to the size of the earth (8,000 miles diameter); an atom would then be about the size of a walnut or a cricket-ball. Now magnify the cricket-ball or atom to a cube of about 100 feet each side; the electron would be about the size of this dot (.) (1/100th of 1 inch diameter). The mind cannot conceive such figures.

About that time (1903), or shortly afterward, the attention of medical men was directed in a critical scientific manner, apart from tradition and empiricism, to the curative effect of certain waters from mineral springs. Laborious research on the part of many workers has revealed the fact that these curative waters contain a number of extremely small metallic particles, endowed with continuous, rapid, oscillatory movement known as the "Brownian movement."

This condition under which these particles are present is known as the "colloidal" condition. The word "colloidal" is really a misnomer, but it has gained currency by long use. The actual state in which these particles exist is that of extreme minuteness; they remain in suspension, being kept up by the continuous molecular bombardment of the surrounding liquid. Natural waters contain these metallic particles in comparative small numbers, and the problem arose how to increase the number and thus the efficiency of these particles in a solution. One method, known as Bredig's method, of effecting this result was by using a high-tension disruptive electric spark under water, between poles of the metal to be dealt with. Solutions containing an almost incredible number of particles of metal were prepared by these means, and it was soon found that these liquids had a very high germicidal power. After a time it gradually became evident that these electric colloids, as the solutions were called, could not be depended upon; they were not stable and were broken down by the presence of electrolytes. The next problem was that of stabilizing these colloidal solutions. As the workers increased in number the proposed methods multiplied. Organic compounds of metals were introduced, but all had drawbacks, such as non-stability, irritation, caustic effect, etc.

A few years later, during a research I was engaged in, I noticed a peculiar action of some metals in inhibiting the growth of bacteria in their neighborhood; as a result of further work in following up this question I exhibited a number of living cultures and photographs of my experiments at the Royal Society and at the Royal Institution in May and June, 1911. The germicidal action of metals in these experiments is, at first sight, very similar to the observed germicidal action of radium, but with this enormous and important difference, that whereas radium kills and destroys the flesh as well as the bacteria, the other metals (in what is now called the colloidal state) kill the bacteria only, and exercise a bland and soothing effect on the animal tissues.

After further work on the subject, entailing about 2,000 experiments, I was able to produce a harmless liquid containing metallic particles in suspension, endowed with the above-described "Brownian" movement. I have called these preparations "Collosols." The germicidal action of colloid metals in suspension has been known for some time, especially during the last seven or eight years, in connection with medical and therapeutic work; but the great drawback in all previous preparations of this character, as has already been pointed out, is that—(1) they are not stable by themselves; (2) they break down instantly when introduced into a liquid containing even a small proportion of common salt, such as the blood (containing 0.7 per cent salt), and are therefore useless for the human body; (3) they are nearly all irritating to the animal tissues. "Collosols" have none of these drawbacks; they are permanently stable, they do not irritate the tissues, salt does not break them down, and they contain so small a proportion of metal, viz., 1 in 2,000, that even a poisonous body like arsenic can be used with impunity. Well-known medical men have stated confidently that the dose is unlimited, as only the bacteria and ferments are killed.



I. II.

Photographs illustrating the preservative effects of "Collosol Argentum."

Two plates of nutrient gelatin exposed on the window-sill for half an hour. No. I had been covered previously with "Collosol Argentum" for five minutes; No. II was untreated; both plates were incubated for forty-eight hours at 20 deg. Cent. No. I is sterile, No. II contains about 350 microbes.

Collosols can be applied topically as a lotion, by intramuscular or intravenous injections, or by the mouth, and from numerous trials made by a large number of medical men, as well as from very many laboratory experiments, it has been proved conclusively that there is no microbe that can withstand the action of collosols, when properly applied, for more than a few minutes.

Silver and mercury "Collosols" of the normal strength (1 in 2,000) were diluted with nine times the quantity of nutrient broth (1 in 20,000), and 10 cubic centimeters of this mixture were infected with two loopfuls of a vigorous culture of *B. coli communis*; after shaking, so as to mix thoroughly, streak cultures were made quickly on agar plates, the first within 10 seconds, then at 2, 4, 6, 8, and 10-minute intervals. These plates were incubated at 37 deg. Cent. for forty-eight hours, and gave the following **results:**

Silver "Collosol" (1 in 20,000) with *B. coli communis*.

After 10 seconds—Growth.
" 2 minutes "
" 4 " "
" 6 " No growth.
" 8 " "
" 10 " "

Mercury "Collosol" (1 in 20,000) with *B. coli communis:*

After 10 seconds—Growth.
" 2 minutes—No growth.
" 4 " "
" 6 " "
" 8 " "
" 10 " "

(In each case the blank or control streak gave a vigorous growth.)

These experiments were repeated with silver and mercury "Collosols" at the normal strength of 1 part in 2,000. In every case *B. coli communis was killed within ten seconds*, the only growth on the agar plates being those of the untreated control streaks. Several comparative tests were made with the *gonococcus* grown on agar plates smeared with fresh blood, with the usual precautions. A plate showing a vigorous growth and answering to the typical tests (that is, Gram-negative, no growth on gelatin or agar at 20 deg. Cent. without fresh blood, but vigorous growth at 37 deg. Cent. on agar with fresh blood, and displaying the well-known *diplococcus* in pus cells) was swamped with "Collosol" silver for two minutes, after which time streak cultures were taken and transplanted to agar plates smeared with fresh blood as before, at intervals of 2, 4, 6, 8, and 10 minutes, and incubated in the usual way at 37 deg. Cent. *Result—No growth whatever.*

I have carried out many series of experiments similar to this; for instance, with a young vigorous growth of *B. tuberculosis*, I found that with "Collosol" silver (1 in 2,000) it was killed in four minutes. With *Staphylococcus pyogenes*, various *Streptococci*, and other pathogenic organisms, I find that all are killed in three or four minutes; in fact, *I know of no microbe that is not killed in laboratory experiments in six minutes.*

It will be argued that laboratory experiments are not of much value, because of the very different conditions in which bacteria exist in the human body; the answer to this objection is that with a safe bactericide, such as Collosols, of which the dose is unlimited, large quantities, such as one pint or more, can be injected intravenously (this has been done thousands of times with other liquids), and it is well known that a fluid injected into the body soon spreads throughout the whole system. In some circumstances it is desirable and even important to apply colloid metals, not only internally but locally, such as in the case of a diseased joint containing incapsulated bacteria (such as the *gonococcus* or *B. tuberculosis*). I have shown that this can be done by means of a very small electric current of about 30 to 40 milliamperes with an E. M. F. of about 50 volts.

Two blocks of solid nutrient gelatin were prepared, 2 inches diameter and 1 inch thick. A current of 35 milliamperes was passed through one of these *A* by means of silver pole plates 1½ inches square, covered with flannel soaked in silver collosol; the current, obtained from a medical battery of 24 dry cells, was kept on for 20 minutes, the negative pole being placed on the top. The other block *B* was arranged in exactly the same manner, and left for 20 minutes, but no current was passed. Stab cultures of *B. coli communis* were made vertically through the center of each block. Three days afterward I noticed a growth along the line of the stabs, and in order to examine these more closely I made a vertical section of each block close to the stab. I then observed that in block *B* without current there was a vigorous growth of *B. coli* throughout the length of the stab, right up to the surface; whereas, in block *A* with current, there was no growth at the surface, nor for the top eighth of an inch, and below that only a feeble growth for the rest of the line of stab. This proves that the negative current of 35 milliamperes had driven the colloidal particles of silver into the gelatin, where they were able to continue their germicidal activity, and that the particles did not soak into the gelatin to any appreciable extent, without the driving action of the electric current.

To show that medical electric currents do not break down collosols, I passed a current of 40 milliamperes from the same 24 cells through 10 ounces of Collosol Argentum contained in a glass vessel for one hour. The same silver pole plates 1½ inches square were used, and were kept about 2 inches apart. After turning off the current the collosol was examined under the ultra-microscope, and it was observed that no change in the "Brownian" movement had taken place.

Much has been said as to the theory of this killing action. How is it brought about? With regard to the radium emanations it is undoubtedly akin to burning; radium sores are in a way similar to burns but take very much longer to heal. Ultra-violet light, even at the temperature of liquid air (—181 deg. Cent.) has apparently a disruptive or bursting action.

It seems probable that the action of colloid metallic particles in killing bacteria is due to another cause. Assuming, as seems reasonable, and as has been definitely stated by some writers, that each metallic colloidal particle carries a charge of electricity, these particles in any definite preparation are all electrified in the same manner—negative, for example, in the case of silver—and are therefore mutually repelled, so that in spite of their constant and exceedingly active movement (about 6,000 times their own diameter per second), they do not and cannot touch each other, and thus do not lose their charge. If, however, a foreign neutral body (such as a microbe) enters the solution, these electrified particles are not repelled from it automatically, but may even be attracted to it if it happens to carry a charge of the opposite polarity by the action of absorption; in any case, being of much greater mass, the microbe will receive the charges of many thousands or millions of particles of metal, and this may very conceivably account for its death.

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[*] Paper read before the Royal Society of Medicine, April 8th, 1914, and published in the *Chemical News*.

Bacteria are measured under the microscope in terms of μ (1/1,000th of a millimeter), and the average size of a coccus may be taken as 1 μ diameter, or in the case of bacilli 1 μ in length. The size of colloidal metallic particles is, however, very much smaller, and they are measured in terms of $\mu\mu$ (1/1,000,000 of a millimeter). According to Zsigmondy, particles of more than 60 or 70 $\mu\mu$ in a liquid sink to the bottom, while those of less than 3 or 4 $\mu\mu$ cannot be seen under the ultramicroscope, even with bright sunlight as the illuminant. Thus the proportionate size of a microbe and the smallest visible metallic colloid particle is about 330:1, or to give a popular example, their relative sizes are as the elephant in the Natural History Museum compared with the shrew mouse underneath.

The number of colloidal particles in a liquid containing 0.05 gramme of gold per liter, or 0.005 per cent, is, according to Zsigmondy, 1,000,000,000 per cubic millimeter; assuming each particle to be 15 $\mu\mu$ diameter, owing to the difference in specific gravity, there would be about double the number of particles of silver. As Collosol Argentum contains 0.05 per cent—or ten times the amount of Zsigmondy's typical solution—the number of particles present would be, in round numbers—

$$1{,}000{,}000{,}000 \times 2 \times 10 \times 1{,}000 \text{ per cubic centimeter} = 20{,}000{,}000{,}000{,}000 \text{ per cubic centimeter of 15 drops.}$$

An illustration of the protective value of "Collosols" is shown in two photographs (Figs. 1 and 2). Two plates of nutrient gelatin peptone, *A* and *B*, were exposed on the window-sill for half an hour. *A* had been previously washed with Collosol Argentum, *B* was untreated. Both plates were then placed in the incubator at 20 deg. Cent. for 48 hours. It will be seen that *A* is sterile, while *B* contains about 350 colonies of microbes. It must be admitted that about an equal number of bacteria in the dust will have fallen on the two plates during the time of exposure side by side; the result shows the *rôle* of colloidal metals in the form of "Collosols" as a protective agent in dressing wounds after operations, and also all smaller scratches, wounds, and sores on the body.

With reference to the medical employment of these preparations, my medical and other friends have, during the past two and one half years, furnished me with very encouraging reports, which seem to warrant these remedies receiving a more extended trial by the medical profession. It is to be hoped that they will receive the attention which they deserve.

Identity of Chemical and Biochemical Laws

The average educated man of the present age probably believes that, while it has long since become impossible to draw a demarkation line between organic and inorganic compounds, the general laws of chemistry cannot be applied to the physiological problems affecting living organisms. The argument that vital force is not mechanical or chemical force, is considered sufficient to terminate any discussion of attempts to solve the problem as to the origin of life on general scientific lines. Hundreds of organic compounds have been prepared synthetically from substances which can themselves be built up in the laboratory from the chemical elements. But it is rightly objected that the methods applied differ radically from those with which Nature works. If a particular organic substance can be produced in the laboratory by submitting other compounds to the action of strong acids and to high temperatures and pressures, that form of synthesis certainly does not tell us anything as to the way in which the plant assimilated its food and prepared that particular substance. It would be wrong to claim any analogy in such instance. But we know now, for instance, that the abstraction of the carbon dioxide from the air, and the restoration of oxygen to the air, can be effected by ultra-violet light, without the intervention of plant chlorophyl, hitherto deemed indispensable, and experimental science seems to have sufficiently advanced to assert that the general laws of chemistry and biochemistry are identical, instead of being opposed to one another.

To prove this was the aim which Prof. Svante Arrhenius, Director of the Nobel Institute of Physical Chemistry at Stockholm, had set himself in delivering three Tyndall lectures on "Identity of Laws in General and Biological Chemistry," at the Royal Institution, on the three Thursdays before Whitsuntide. Prof. Arrhenius has himself chiefly investigated this field of late. We cannot follow him into the details of those researches; but we will refer to the chief results. He showed in the first lecture that certain chemical reactions had been observed which seemed to be incompatible with the laws of general chemistry, but which had their analogies in biochemistry. The difficulties in the latter cases were therefore not characteristic of vital processes, as had been assumed, and the chemical study threw light on the biochemical processes, and *vice versa*. In the coagulation of proteins and in the decay of organic substances, for instance, the catalytic effects mainly depended upon the presence of hydrogen or of hydroxyl ions, and this again depended upon the presence of small traces of acids or bases. The acidity changed during the progress of the decay, the character of the digestion (by means of pepsin) changed with it, so that the digestion did not proceed proportionally to the time, but proportionally to the square root of the time, just as in the analogous chemical case of the action of ammonia on ethyl acetate; the products of this reaction were ammonium acetate and alcohol. The peculiar deviation from the general laws in the inversion of cane-sugar by the aid of invertase (the yeast enzyme) was a similar case.

These digestion experiments, etc., had been made *in vitro*, in glass vessels. In the living body the reactions were more complicated, but they followed the same laws. That had been proved from the inversion of cane-sugar by living yeast-cells and by digestion experiments with dogs, studied especially in St. Petersburg by Pawlow and his pupils. We confess that we were much more struck by the general regularity and similarity of the digestion curves than by certain irregularities to which Prof. Arrhenius directed attention; considering that as many as forty fistulæ were placed in the alimentary ducts of the same dog, one could only wonder that normal results were obtained at all. But the fermentation of milk by rennet, the destruction of bacteria—studied especially in London by Martin and Miss Chick—followed again the same laws, and the influence of a temperature rise of a few degrees was as remarkable as in many chemical experiments. Even the possibility of the synthetical building up of organic substances by the aid of enzymes had finally been demonstrated, Prof. Arrhenius explained in the third lecture. Enzymes, as a rule, broke up complex compounds into compounds of simpler constitution. In 1898, Van't Hoff had predicted that it should be possible to build the original substance up again by the action on the decomposition products of the same enzymes which had effected the decomposition; the confirmation of this prediction had long been delayed, but had been realized quite recently. When casein was decomposed by pepsin, *e. g.*, and the pepsin afterward allowed to act on the resulting albumoses, a protein substance had indeed been obtained, but it was not the original casein; the success had therefore only been partial so far.

Again, the lecturer continued, the equilibrium laws concerning the partition of a substance between the different solvents or substances with which it could react were not different for general chemistry and for biochemistry. It had, for instance, long been known that blood corpuscles took up a very much larger proportion of certain salts or poisons than the blood serum; but similar enormous differences were observed when different salts were brought into mixtures of acetone and alcohol, for instance. Thus the blood corpuscles took up 450 times as much silver nitrate, 590 times as much acetic acid, 750 times as much caustic soda, and more than 2,000 times as much mercuric chloride (one of the most deadly poisons) as the so-called physiological salt solution (0.9 per cent solution of sodium chloride in water) did. These researches had a very important bearing on the action of poisons, on the one hand, and on the immunization against bacterial or other poisons, on the other. The diphtheria poison, or toxin, was neutralized in the system by the antitoxin injected, just as a base was neutralized by an acid. The peculiar phenomena of hæmolysis and precipitutions (injecting the blood of one animal into another), even the peculiar immunity phenomena connected with the names of Ehrlich and of Danysz, had their parallels in ordinary chemistry; the growth and decline of a fever gave the same curve as the growth and decline of the respective bacteria; and both the active immunity (secured by the injection of an anti-toxin) and the passive immunity (by injection of a weak culture of the same bacterium, as in vaccination against small-pox and against rabies) could be accounted for on general lines. Though, therefore, science remains far removed from the possibility of explaining vital phenomena, Prof. Arrhenius was able to make out a good case for his claims as to the identity of the laws of general chemistry and of biochemistry.—*Engineering.*

Man and the Mammoth in America*

By George Frederick Wright

The recent discovery of a well-preserved skeleton of *Mammoth americanum* in Farmington, Conn., gives new interest to the question of the coexistence of man with the mammoth in America, and to the further question of the dates of the extinction of the mammoth and of the close of the Glacial period. The discovery was made late in August, 1913, by some Italian workmen who were digging a trench on the estate of Mrs. A. A. Pope. The workmen on striking the skull thought at first that it was a tree trunk, and hence injured it somewhat. On discovering their mistake they reported it to Mrs. Pope as a "black devil." Mrs. Pope promptly brought it to the attention of Mr. Charles Schuchert of the Peabody Museum of Yale University, who has given an account of the discovery in the April number of the *American Journal of Science.*

The bones were nearly all together in the place where the animal died, but one of the tusks was 23 feet away and on ground which was 2 feet higher than the rest of the skeleton. Though the animal was not full grown, the skeleton when mounted will stand about 8 feet 2 inches at the shoulder, with a length of 13 feet 2 inches from the tip of the premaxillary bone to the curve of the tail.

Special interest in this discovery is aroused by the evidence it gives of the recent extinction of the mammoth in North America, and of its being a contemporary here with man. Evidently the animal under consideration was entombed shortly after the vanishing of the ice sheet from the highlands of Connecticut; for the skeleton was found in a shallow trough (or kettle hole) on the surface of the "till," or direct glacial deposit. As no organic matter or oxidized till was found beneath the skeleton, and as very little vegetal matter is seen in the boulderless clay surrounding the bones, it is evident that the entombment occurred shortly after the ice had withdrawn, and before much vegetation had spread over the glaciated surface. The animal was buried by 4 feet of clay, over which 18 inches of turf had accumulated. Dr. Schuchert estimates that the clay could have accumulated "in a few hundred years, and that the stingy turf apparently did not take much more time to form. Then, too, the skeleton shows no mineralization nor petrifaction, and is but little discolored to a light brown by the waters of the swamp."

This evidence of recent burial agrees with that concerning two other specimens found in similar condition in the general vicinity, the skeletons of which "look like bones buried but a few hundred years," while between the ribs of one of these (the Warren skeleton of the American Museum of Natural History) "lay from 4 to 6 bushels of vegetable food, largely coniferous and much like spruce or hemlock." Though this is not direct evidence of man's coexistence in America with the mammoth, the recent date of these entombments would make them contemporary with the various relics of man which have been reported in glacial deposits.

This evidence, added to that which has heretofore been adduced[1] would seem to put the coexistence of man and the mammoth in America beyond question, especially as the elephant mounds in Ohio and Wisconsin, and the prehistoric catlinite pipes shaped like the elephant, found in Iowa, give testimony that is unconnected with any theory of geological agencies.

Thus, all over the northern hemisphere evidence points to the recent close of the glacial period, and in connection with it, or following it, a wholesale destruction of many animal species. In North America, the following kinds of great quadrupeds disappeared during that period or shortly afterward: Camels, llamas, horses, tapirs, mastodons, elephants, and three species of giant sloths, of which the *Megalonyx* is most prominent, the latest discovery of which has recently been made by Mr. Gallup, in Norwalk, Ohio. This like the mammoth in Farmington, occurred in a partially filled "kettle hole," left on the withdrawal of the continental ice sheet.

As these remains are found in post-glacial deposits, it is evident that the advance of the continental ice sheet was not the direct cause of the destruction of these species. But in the words of Prof. Osborn, "It is more in accord with the facts to say that the glacial period in North America *originated certain new conditions of life which directly or indirectly resulted in extinction.* These conditions include diminished herds, enforced migrations, the possible overcrowding of certain southerly areas, changed conditions of feeding, disturbances in the period of mating and reproduction, new relations with various enemies, aridity, and deforestation; in short, a host of indirect causes." (*The Age of Mammals*, p. 501.)

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* Reprinted from *Records of the Past.*

[1] See *Records of the Past*, vol. ii, pp. 243-253.

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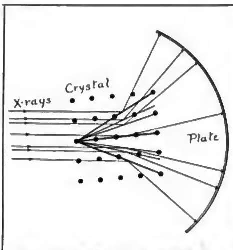

Fig. 1.—Diagram illustrating reflection of X-rays by crystals.

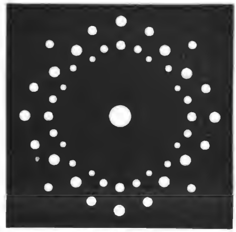

Fig. 2.—X-ray diffraction pattern with potassium chloride.

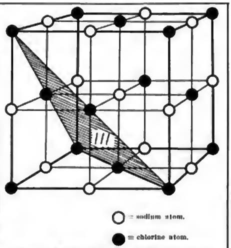

Fig. 3.—Rock-salt crystal. Distance between atoms 0.0000000101 inch.

New Light on the Structure of Matter

Molecular Architecture Revealed by Roentgen Rays

By Arthur H. Compton, Princeton, N. J.

One of the most interesting developments in modern physics is the recent discovery that Roentgen rays can be reflected and diffracted by means of crystals. As an immediate result of this discovery, not only has the true nature of X-rays themselves been learned, but scientists have been able to explore the inner structure of crystals, learning the arrangement of, and measuring the distance between the atoms of which they are built. It even seems as though we may be able to probe still deeper by this means, and find out how the atoms themselves are made.

WHAT ARE X-RAYS?

Though the nature of X-rays has been generally supposed to be similar to that of light, that is, ether vibration of very high frequency, there were those who still defended other hypotheses. There are certain differences which were hard to explain. No one had been able to reflect X-rays regularly, as light is reflected from a mirror; a diffraction grating had never been constructed which would disperse the rays; and the remarkable penetrating power of these rays offered a striking contrast to the action of light waves. These things could all be explained by supposing that the wave-length of Roentgen rays was extremely short, about 1/1,000th that of light, but there were other hypotheses which seemed to give a fuller explanation of some phenomena.[1]

The distance between the molecules in a solid is about a hundred millionth of a centimeter, and supposing the wave length of X rays to be a thousandth that of light, these waves would not be very much shorter. So it occurred to Prof. Laue that, if the molecules were arranged regularly, as they are in crystals, they ought to act as a diffraction grating and disperse the rays in much the same way as an ordinary diffraction grating disperses light. Messrs. Friedrich and Knipping tried the experiment by passing a fine beam of X-rays through a crystal of zinc-blende, a short distance behind which was placed a photographic plate. When they developed the negative, they found a remarkable group of spots, arranged symmetrically on four sides of the central image, as in Fig. 2. The true explanation of these spots was given by Mr. W. L. Bragg. He explained each spot on the photographs as being due to the regular reflection of the beam of X-rays from a plane in the crystal, which is especially rich in atoms. For instance, if the atoms are arranged in a simple cubic pattern, as in Fig. 1, the rays would be partially reflected from planes, such as those represented by heavy lines, which contain a relatively large number of atoms, but not from planes taken at random, which do not include many atoms.

The cleavage face of a crystal is very rich in atoms, so to test his explanation Mr. Bragg allowed a beam of X-rays to fall on a cleavage face of a crystal, and found, as he had predicted, that an image was produced on the photographic plate at the angle of reflection. But he noticed that as the angle of incidence was changed, there were certain angles at which the reflection was exceptionally strong. Thus, as in Fig. 5, which represents the intensity of the reflected beam for different angles, at certain very definite positions the reflected beam increased suddenly in intensity. These positions of strong reflection could be explained in only one way, as real spectrum lines in the X-rays—radiation of definite wave-length. This explanation led at once to a definite knowledge of the nature of X-rays.

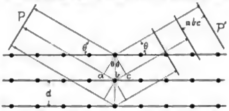

Fig. 4.—Diagram illustrating formation of X-ray spectrum produced by reflection from crystal surface.

In the ordinary X-ray bulb the rays are produced by shooting a stream of electrons from the cathode against a metal plate. When they strike this plate they send out ether vibrations. It is just like shooting at a target with a rapid-fire gun, the bullets replacing the electrons, and the powder the electric field. When each bullet strikes the target, the sudden stopping of its motion sends out a "pulse" of compression through the air which reaches our ears as a thud. If the target is made properly, it will vibrate when struck, and we hear it ring. In the same way, when an electron strikes an atom in the metal target of the X-ray bulb, it is suddenly stopped, giving out an ether "pulse." At the same time it sets the electrons in the atom itself to vibrating with their natural frequency, which is characteristic of the particular atom. Thus the X-rays are composed of a series of very intense pulses, due to the collisions of the electrons, along with one or more trains of waves of definite wave-length, caused by the resonance of the electrons in the atoms of the target.

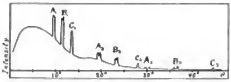

Fig. 5.—Spectrum of X-rays from platinum target reflected by crystal of rock-salt.

When an X-ray pulse strikes the cleavage face of a crystal at a definite angle, as in Fig. 4, a part of it is reflected by each layer of atoms. When its reflection from the first layer of atoms reaches P', the reflection from the second layer is a distance a, b, c or $2d \sin \theta$ behind it, and the reflections from the lower planes are spaced at equal distances behind. Thus the pulse at P is reflected to P' as a series of pulses of definite frequency. It is just the same principle as when a noise in front of a flight of steps or a wicket fence is echoed back as a musical tone. If the pulses are scattered at irregular intervals, each will produce a separate series of vibrations at P', but if they come in a train of waves whose wave-length is $2d \sin \theta$, or some simple harmonic of it, they will reinforce each other at P' and produce an especially strong image. This will occur when

$$n\lambda = 2d \sin \theta; \qquad (1)$$

where n is an integer, and λ is the wave-length of the resonant rays.

Since there are only a very few periods of natural vibration of the atom, there will be only a few definite values of λ, so that this equation will be satisfied for only certain particular values of θ. The reflection of the scattered pulses, however, will be present at all angles. So as θ is increased, there will be a comparatively uniform intensity of reflected rays due to the irregular pulses, and at certain definite angles a sudden increase in intensity due to the resonant rays. This is shown in Fig. 5, which is the spectrum of X-rays from a platinum target as reflected by a crystal of rock-salt. It will be noticed in this diagram that the prominences repeat themselves as θ increases. The different series of lines represent different orders of spectra, n for the first order being 1, for the second 2, and so forth. In this manner our theory of the nature of X-rays accounts perfectly for the form of these spectra.

THE STRUCTURE OF CRYSTALS.

At this time no one knew whether it was the molecules or the individual atoms which did the reflecting. Whatever the reflecting centers were, however, there was now a means of finding out how they were arranged in the crystal. Mr. Bragg imagined a number of different arrangements of these centers, and on the theory that each spot in Friedrich and Knipping's photographs was a partial reflection of the primary beam by some plane rich in atoms, he calculated where the spots should be found for each arrangement. It was found that nothing but a simple cubical design could account satisfactorily for the spots obtained with such crystals as salt, potassium chloride, etc. He was now able to decide whether it was the atoms or the molecules which did the reflecting. By comparing the intensity of the different orders of spectra when the rays were reflected from the (111) plane (Fig. 3), it was shown that the alternate planes of centers differed in reflecting power. On the assumption that it is the individual atoms which act as the reflectors, this was easily accounted for by placing layers of sodium atoms and chlorine atoms alternately parallel to the (111) plane. This gives at once the arrangement shown in Fig. 3, where the open circles represent sodium, and the solid ones chlorine atoms.

It is interesting to notice that there is no evidence in

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[1] The theory other than the wave theory which received most support was one put forward by Prof. W. H. Bragg in 1910. According to this theory, X rays are corpuscles, each composed of an electron and an equal positive charge, which travel with nearly the velocity of light. This theory was made to account for the fact that the "emergent" secondary radiation is stronger than the "incident" radiation, when a beam of X rays passes through matter. Even this fact, however, was shown by Prof. O. W. Richardson to be consistent with the wave theory of X rays.

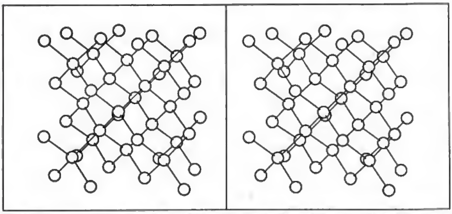


Fig. 6.—Arrangement of atoms in a diamond (Bragg). Distance between atoms = 0.000000015 centimeter. To be looked at in stereoscope.

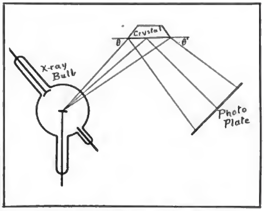


Fig. 7.—Diagram of Moseley's method of photographing X-ray spectra.

this arrangement that the atoms are combined into molecules. A sodium atom is no more closely connected with one particular chlorine atom than with any other. In fact, a crystal, such as the one shown in Fig. 3, may have an unequal number of sodium and chlorine atoms. None of the crystals so far examined have given evidence of any molecular structure. Is it possible that, in the solid state, matter loses its molecular structure, each atom being connected with the whole mass instead of to that particular group of atoms which form its molecule? It would seem to be so, at least for crystals.

Now that the arrangement of the atoms is known, it is easy to calculate their distance apart, and thus to define completely the structure of the crystal. The number of molecules in a gramme of sodium chloride is

$$\frac{6.22\times10^{23}}{58.46}$$

where 58.46 is the molecular weight of NaCl; and if its density is 2.167, there are

$$\frac{58.46\quad 2.167}{6.22\times10^{23}}=2.31\times10^{22}$$

molecules, or 4.62×10^{22} atoms, in a cubic centimeter. Since the atoms are arranged cubically, their distance apart is

$$d=\sqrt[3]{\frac{1}{4.62\times10^{22}}}=2.79\times10^{-8}\text{ centimeters,}$$

a trifle over one hundred millionth of an inch. Thus, along the edge of a salt crystal an inch long, there are arranged a hundred million atoms.

In much this same way Prof. W. H. Bragg has determined the structure of the diamond. In this case the atoms are all the same kind—carbon. The arrangement he finds for these atoms is shown stereoscopically in Fig. 6. Each atom may be thought of as bound to four other atoms, arranged at the corners of a tetrahedron. This is in accord with the fact that carbon has four chemical bonds, and is in good agreement with the structure of the diamond as determined by the methods of crystallography.

THE STUDY OF X-RAY SPECTRA.

As we now know d, the distance between the atoms in the crystal, we can easily determine the wave-length corresponding to the different lines in the X-ray spectrum. For instance, for the B_1 line of platinum, if it is reflected from rock-salt, when $n=1$, $\theta=11$ degrees 28 minutes, so that equation (1) becomes

$$1\times\lambda_{B}=2\times2.78\times10^{-8}\times\sin\text{ (10 degrees 28 minutes)}$$

$$\lambda_{B}=1.100\times10^{-8}\text{ centimeters.}$$

Since the wave-length of sodium light is

$$\lambda_{D}=5.89\times10^{-5}\text{ centimeters,}$$

the wave-length of these X-rays is about one five-thousandth that of light.

One of the finest pieces of work done in the study of X-ray spectra is that of Mr. H. G. J. Moseley,[5] in which he compared the X-ray spectra of a large number of different metals. These metals were used successively as the target of an X-ray bulb, and the rays were reflected from a large crystal of potassium ferrocyanide on to the photographic plate (Fig. 7). Each exposure required about five minutes, and gave the spectrum through a range of wave-lengths of about 30 per cent. Fig. 8 represents the third order spectra which Moseley obtained of all the metals of atomic weight between 40 and 65, with the exception of scandium. The remarkable thing about these spectra is their similarity for the different elements. The square root of the frequency which corresponds to the more prominent line of these spectra has been shown to change by a constant difference as we pass from element to element down Mendeljeff's periodic table. This is the only property of matter which has been shown to vary uniformly from element to element.

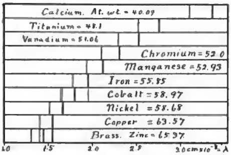


Fig. 8.—X-ray spectra of ten metals, according to Moseley.

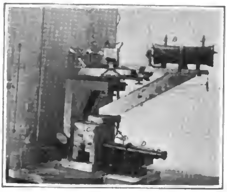
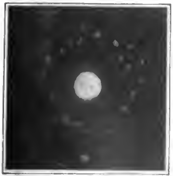


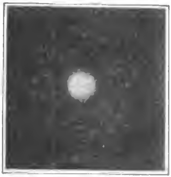
Fig. 9.—Apparatus employed in the study of crystal structure by means of X-rays.

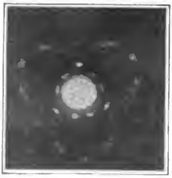
A, crystal; *B*, ionization chamber; *C*, electroscope; *D*, microscope. The X-ray tube is hidden by the partition in the background.

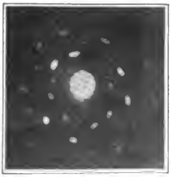
It is evident that this affords a convenient means of finding out where elements are missing. For instance, it is easy to see that an element is missing between calcium and titanium, and even if scandium were not known it would be possible to predict its existence and give approximately its atomic weight and its general characteristics. Moreover, it affords a powerful method of chemical analysis. For instance, the cobalt contained only 0.8 per cent nickel, and the nickel line appears very distinctly in the cobalt spectrum. The ease with which these spectra can be obtained would seem to make the method of considerable value to the qualitative chemist.[6]

But possibly the most interesting result of this research is the light it throws upon the structure of the atom itself. A number of different theories have been proposed which explain the atom as a nucleus of "positive electricity" about which electrons revolve in orbits, as do the planets around the sun; but none of them have been sufficiently confirmed by experiment to be generally accepted. From the uniformity of the spectra of these elements, Moseley has been able to show pretty definitely that the number of electrons in an atom is equal to the number of the place of the element in Mendeljeff's table. That is, if any element is the *Nth* in the periodic table, counting hydrogen as 1, helium as 2, etc., the total number of electrons in the atom is *N*. Thus each element contains just one more electron per atom than the element next lighter. It seems probable, from his results, that these electrons revolve about the central positive nucleus in concentric rings, much in the same manner as the rings revolve about Saturn. If this is true, there are probably four atoms in the inner









Photographs by W. L. Bragg, reproduced from the *Proceedings* of the Royal Society.

Fig. 10.—Potassium chloride.

Fig. 11.—Rock-salt, 2.5 mm. thick.

Fig. 12.—Fluorspar.

Fig. 13.—Rock-salt.

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[5] "High-frequency Spectra of the Elements," *Philosophical Magazine*, December, 1913.

[6] In the last number of the *Philosophical Magazine* (April, 1914), Mr. Moseley has given the X-ray spectra of thirty-nine different elements, showing that this constant change in the character of the spectra holds for all the elements, from aluminium to gold. He shows that gold is the seventy-ninth element in the order of atomic weights, and has predicted the position of three new elements. The position of these elements is (1) between molybdenum and ruthenium, (2) between neodymium and samarium, and (3) between tungsten and osmium. Chemists are now at work hunting for these elements.

ring for the elements whose spectra are shown; but this has not yet been established definitely.*

It is hard to tell to what these researches may lead in the near future. Already the structure of a dozen different crystals has been determined, the nature of X-rays has been found out, and light has been thrown upon the manner in which the atom itself is built. It may be, as Sir Oliver Lodge suggests, that the study of reflection of X-rays by crystals will form by itself an important branch of modern physics.

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* This theory of the structure of the atom was proposed by Dr. N. Bohr (*Philosophical Magazine*, July, August, September, 1913). Moseley showed that his photographs confirmed this theory in a very striking manner.

The Metric System*

By Alexander Siemens

Since its introduction into the United Kingdom, the metric system or question has had its ups and downs. Surely it is very curious that, although in 1862 a Parliamentary Commission recommended its introduction—a recommendation since repeated two or three times—and though a bill was actually passed by the House of Lords, the metric system has not been adopted in this country. Why do people go on agitating? Well, the reason is the necessity for such a system. The facilities for intercommunication between various countries have a great deal to do with the continual agitation to introduce an international system of weights and measures. You may say the first person who put this down in black and white was James Watt. Writing to a friend in 1783 he said it was very awkward that the scientific results of workers in various countries could not be compared readily because of the measurements and weights being so different, and he proposed that they should agitate for the adoption of an international unit of weights and measures for scientific purposes. He wrote to French savants on the subject, and the result of the agitation was that in 1790 Prince Talleyrand brought in a bill before the Legislative Assembly of France proposing that a Commission should be nominated to deliberate on this subject. It was a provision of that measure that the Royal Society of London and the French Academy should nominate the members of the Commission because it was agreed that the Commission ought to be an international affair and not merely a national one. The Royal Society would not agree to it because, as you know, England and France were at war at that time. Eventually, however, some other countries joined and constituted a Commission.

Another feature of the metric system was also suggested by Watt. He suggested that the unit of length should be cubed, a vessel constructed, filled with water at its greatest density, and that that should be the unit of weight. This cube should be the unit of capacity. In carrying out this idea insuperable difficulties have arisen of an absolutely mechanical nature, and so a kilogramme is not any more a decimeter cubed and filled with water, but it is a piece of platinum kept in Paris at a certain temperature and at a certain barometric pressure. But the difference is very slight and does not affect the value of this co-relation between length, capacity and weight. That is just the same as the standard of British measure—in fact, the real standards of English weights and measures were burned in 1835 in the Houses of Parliament and had to be reproduced afterward as best they could. Secondary standards have now been made and have been distributed over the country, so that there is no danger of the standards being lost again.

After giving you this short history of the beginning of the metric system, I wish to direct your attention to the greatly different circumstances of communication between the various countries from what formerly existed. The interchange of products between the various countries has increased very much, and it is to the interests of everybody that this interchange should be facilitated as much as possible. One of the greatest facilities is that the same weights and measures should be used everywhere. Now the real requirements of such an international system are two in number. One is that the measures and weights should have the same base ratio throughout; that means to say one pound in the English system should be 16 ounces; one ounce should be 16 drams; one foot 16 inches; one yard 16 feet, and so on. That would be a system with the same base ratio throughout. Only 16 is not a good one. I am, of course, aware that people say 12 is a good ratio because there are so many aliquot factors in 12—three times four, twice six—and that consequently 12 is handy. We are, however, faced by the fact that all people on earth who count, count by tens, and that has fixed the base ratio for any international system. If you attempt to put in any other ratio it would lead to confusion, and would not be so convenient. Therefore the base ratio of 10 is essential.

Now as regard a little more of the history of the metric system. In 1861, the old Federation of German States instructed a Commission to propose a national system of weights and measures, and after they had deliberated a short time they came back to the Federation and said, "We must say that the only sensible thing"—the only thing that would justify the upsetting of the old measures which were very confusing in Germany at the time—"the only reason for disturbing people and introducing new weights and measures can be to have an international system." At that time the metric system was not as widely introduced as now, and the Commission very carefully went into the question whether they should adopt the English or the French system of weights and measures. It must be remembered that the superiority of England at that time was still very overpowering. It was a little less so than in 1850, but still it was preponderant. The United States and Colonies of England all had the English system of weights and measures, so this Commission, consisting of sensible men, might have thought: "We will go with the majority of the manufacturing people and adopt their weights and measures." But when they saw the English weights and measures and went into them, they unanimously decided that the metric system was the only possible international system. In the metric system there is the same base ratio and divisions everywhere, so you have to learn nothing. It is the same base ratio as you use in calculation. I remember in 1895 I had to give evidence before the Parliamentary Committee on Weights and Measures, and I handed in a German school-book on arithmetic. The Committee said: "How many pages are devoted to the metric system?" I showed them that on the back cover there was a note: "Remember a hectoliter is 100 liters; a kilogramme is 1,000 grammes." The other things were so self-evident that it was considered unnecessary to say anything about them.

The Commission instituted by the old Federation of German States submitted their proposals to the Reichstag in due course; then came the year 1866, which delayed the introduction somewhat, but in 1868 the Act was passed that the metric system should be permissible from January 1st, 1870, and compulsory from January 1st, 1872. This disposes of the idea that the metric system can only be introduced in times of great commotion and so on. The date of the introduction of the metric system was decided upon long before anybody knew anything about the Franco-Prussian War, and was, therefore, introduced rather in spite of it than as a consequence of it. About the same time a Committee was appointed by the English Parliament to report on the introduction of the metric system, and after hearing all sorts of witnesses, they reported in 1862 that "in their opinion it would involve almost as much difficulty to create a special decimal system of our own as simply to adopt the decimal metric system in common with other nations. Furthermore, if we did so create a national system we would in all likelihood have to change it again in a few years into an international system owing to the increase of commerce and intercourse between nations."

More than fifty years ago the upshot was that the Committee said it would be a waste of energy to introduce a special English system because, owing to the ever-increasing intercourse between nations, the nations would be forced into the adoption of an international system whether they liked it or not. That is the real reason why the Decimal Association believes that the metric system is coming. It may be coming slowly, especially here in England—we cannot help that—but if you consider this point of view, that the international intercommunication is every increasing, that the nations are becoming more and more dependent upon the produce of other nations, you will see—you must come to the conclusion that an international system of weights and measures is desirable, and that the refusal of such a system will impede progress.

What are the objections? The first that is made is to the decimal point. Owing to the base ratio being 10, and 10 throughout, there is no necessity to use a decimal point. For instance, anybody making drawings puts all the dimensions on the drawings in millimeters. That has two advantages. You need not put millimeters every time as you put feet and inches (′, ″), and it avoids a lot of misunderstanding if the drawing has not been very carefully figured. 1′ 1″ is often taken for 11 inches, 2′ 4″ for 24 inches, and all that sort of thing, but if you use millimeters you have not that difficulty.

The decimal point objection is really non-existent because you always take the next lower unit if you find that what you want to express is less than the higher unit, and that is generally quite sufficient. The second objection taken is the size of the unit. That really is an argument that shows into what desperate straits the opponents of the system have reached to find an objection, because I cannot for the life of me see that the meter and the yard are so very much different. Nor are a half-kilogramme and a pound so very unlike each other.

The next thing is that the opponents of the compulsory introduction of the metric system say: "Well, you have got all you want, you have permission to use the metric weights, the Board of Trade will verify them for you; they have the standards—so what more do you want?" That is just it. Do not these people see that in compelling manufacturers and traders to have two standards, one for home consumption, and one for dealing with metric countries, they handicap the manufacturers and traders here? And there is another point of view. There was a discussion before the Institute of Inspectors of Weights and Measures on the metric system; they are the people who go about among all the tradespeople and have to verify weights and measures, and they ought to know their business. One inspector said that "from the inspector's point of view there is one point which advocates should not favor, and that is the argument that the proposed general Act should be permissive. To have two sets of weights on the shop counter at the same time is not wise. We know what it would be to have a 14-pound set and a kilogramme set alongside the scale; the changes would be rung. The kilogramme is very near the size of a 2-pound weight; the meter near the length of the yard, and the liter near the size of a quart. With these facts before us, the Act should, in our opinion, be compulsory."

These are the two arguments: So long as it is permissive, people who deal with metric countries have to have two standards, and they are handicapped in that way, and poor people are exposed to the danger of being defrauded.

The last objection is on the ground of cost. In order to have a fair idea of what the cost would be, it is preferable to examine in detail how various interests would be affected if the metric system were made compulsory after a transition period of, say, two years. Taking first the case of the retail trader with whom the general public have most of their dealings. I think it fair to quote an inspector of weights and measures who spoke in the discussion just now alluded to. He said: "The change to the metric weights and measures would really be very little cost to the shopkeeper, but he does not realize that this is the case. The shopkeeper imagines that the whole of the weighing machines and weights have to be changed, and it is the weighing instruments that are the greatest factor with him. The effect so far as weights and measures are concerned is very small indeed. It does not cost much to change either his weights or his measures, and I refer to measures of length as well as to those of capacity. With regard to the changing of lever machines, we know as inspectors that it is a very common thing for a weighing-machine maker to have to change the whole of his steel-yard markings and to have to rub out the old markings and to mark it anew. In this case it would be a very easy thing to change the markings, which would also apply to platform machines and counter-poise weights. The cost would be very small indeed." We may take it on the authority of the persons whose business it is to know everything about the weights and measures of the retail trade that the cost of the change would not be an insuperable obstacle.

The next interest to consider is the textile trade. Here, the opponents of the system contend, the cost of the change would be appalling, because all present looms would become obsolete and would have to be replaced by new ones adapted to produce metric widths of fabrics. I had better take that with the engineering trade, because about that the same is said. I say in reply to all these arguments, "What are you doing now? Are you not exporting to metric countries, are not engineers exporting to metric countries? Have not we in our works plenty of metric dimensions to manufacture to; have we ever found any difficulty in doing it? Have we ever had to introduce new machinery specially to make a metric thing? Never!" Even leading screws of English pitch can be used to produce screws of French pitch and *vice versa*. You must put in one wheel with 127 teeth which makes the changes right. You will find you are absolutely correct. When before a Parliamentary Committee I was asked: "Seeing that in the cotton trade the standard make is what is called 79 inches, 37½ yards, 8¼ pound shirting—which is known all the world over—would it not in some way damage the reputation of the shirting if the figures had to be recalculated in all the markets of the world?" Well, at the time I had not sufficient time in which to make the calculation. What do you get when you recalculate? Seventy-nine inches are 2 meters within one third of 1 per cent; 37.5 yards are equal to 34 meters to within one third of 1 per cent; and 8¼ pounds are 3¾ kilogrammes. So you see you have been entertaining angels unawares. You have been manufacturing to metric measure. So why say it is difficult? The general experience is that wherever the metric system has been introduced it has at once been accepted as by far the simplest and easiest to comprehend, while it has the great advantage of being international, which is more and more necessary nowadays where the intercourse between countries is increasing.

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* From a report published by the Decimal Association of an address to the members of the Bradford Textile Society and of other Trade Organizations at Bradford, and reported in *Nature*.

In the Open Yellow Pine Forests of Washington and Oregon a collapsible plow is being used in digging fire lines to stop surface fires. The plow can be dismantled and folded into a compact form, so that it can be packed on horseback, and weighs only 40 pounds. When in use, one man with a horse can do the work of twenty or more men working with shovels.

A Built-up Model Yacht

Directions for Its Construction

By F. D. Banham

A METHOD of building a boat is here described which is far less laborious than boring and chiseling out a solid block; the hull, in the particular model described, being made by taking three pieces of board, cut to the dimensions given later, and screwing the pieces temporarily together, one above the other (Fig. 1), and shaping the outside of the hull to the correct shape; afterward taking apart the three pieces and cutting out the center of each separate board with a pad-saw. The three pieces are then reassembled permanently to form the finished hull. The plans are for a 2-foot over-all yacht. If another size is desired, proportional dimensions can be taken.

For the amateur, straight grained sugar or yellow pine, or redwood, are the easiest to work. Three pieces finished smooth on each side are required. One piece, 25 by 6½ by ⅞ inch; one 24 by 6 by ⅞ inch; one 20 by 5 by 1¼ inch. Lay out the design to full size on a sheet of paper; follow out the sketch as closely as possible, being careful to get good easy curves. From the sectional curves taken at points *a b c* (Fig. 2) the width at these points on each layer, or board, can be obtained. Make a plan of the top surface of each layer on the board from which it is to be cut, and saw just outside of the line, say $\frac{1}{16}$ inch. At the point *b* on each layer draw a line at right angles to the lengthwise line, as a guide when assembling the pieces together before shaping the hull. When each piece is cut roughly to shape they can be screwed together with say 2 screws each. To aid in getting the correct shape, 3 molds should be made from thick cardboard or thin wood. Three rectangular pieces about 5 by 8 inches should be made, and the outline of the sections at *a b c*, as shown in Figs. 1 and 2, should be drawn on the wood or card, and a piece cut out carefully to the line.

After shaping the hull on the outside till it fits the molds at their respective places, it can be taken apart again; care should be used not to break the edges. With a key-hole saw, or pad-saw, cut out the center of all but the bottom layer (Fig. 4), cut on the slant where needed to follow the outline of the outside; ⅜ inch along the center of the boat will be thick enough, and at the bow and stern where the slant is greater from ¾ to 1 inch should be left for strength and to leave enough in which to drive the fastening nails. After cutting out the center of the layers they are ready for gluing and nailing together. Nail every two inches along the edge with about No. 18 gage by 1½-inch wire brads.

The hull being assembled, it can be laid upside down and a groove cut down the center of the bottom layer about ⅛ inch deep for the keel plate to fit in. The plate should be a fairly tight fit in the groove. The keel can be cut from a sheet of iron or brass 3/64 or ⅛ inch thick. The forward and after edges should be filed to a thin edge.

The lead bulb is made in two pieces, one on each side of the keel plate, and the total weight will be about five or six pounds for bulb and keel. If shaped as shown, one wood pattern will do for both sides. A wood pattern is made the shape of the lead bulb. Each half of the bulb will be about one half inch thick, 6 inches long, and 1¾ inches deep. A mold is then made with the wood pattern in sand, or plaster of Paris, which should be carefully dried before using, and the molten lead can then be poured in the mold. When cool two $\frac{3}{16}$ or ¼-inch holes should be drilled through bulb and pin, and two soft brass rivets used to hold the bulb to the keel-pin. If no facilities for drilling are available the bulbs can be soft-soldered to the keel. Three pins of ¼-inch diameter rod are fitted to the top edge of the keel plate, and are held in place by sawing or filing a slot, down one end of the pin, for about ½ inch, to fit over the edge of the keel, and the other end is threaded to take a ¼-inch nut. The slotted end is slipped over the edge of the keel and a cross-hole is drilled through pin and plate and a wire rivet is driven in the hole. Three ¼-inch holes are drilled up through the bottom layer of the hull for the pins to pass through, and a nut and washer holds the keel firmly in place. Put some thick paint or putty in the groove before finally screwing keel in position.

Before putting on the deck, curve or camber the top edge of the hull; in the center of the boat the curve will be about ⅛ or $\frac{3}{16}$ inch below the straight edge (Figs. 3 and 5). The mast steps in at the distance shown (Fig. 3). The best way is to set in a brass tube of about ½ inch inside bore so that the mast can be taken out when desired. An old fishing rod joint makes a good fitting for the bottom end of the mast. The bottom end of the brass tube should be tightly plugged with a wood or metal plug so that no water can enter the hull from this point. The deck should be of ¼-inch wood, and can be cut slightly large, and finished flush with the hull when screwed in place.

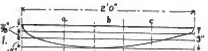


Fig. 1.

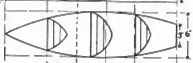
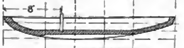


Fig. 2.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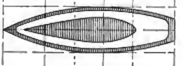


Fig. 4.

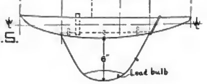


Fig. 5.

If a rudder is to be used, another hole will be needed through the deck to the underside of the hull, just behind and parallel with the after edge of the keel. This is to allow a small brass tube of about $\frac{3}{16}$-inch bore to pass through. The rudder post then passes up through the tube. The tiller is bent aft, parallel with the deck and about ⅜-inch above it, and is about 3 inches long. Small lead weights are made to clamp or screw along the tiller, and so, by operating the rudder, as the boat heels over when sailing, keeps it on a straight course. Putty or thick shellac should be placed around where the tube passes through the hull and deck, to prevent water entering the hull. The rudder post is a brass wire passing freely through the tube and the rudder can be made of sheet brass about $\frac{1}{16}$-inch thick and soldered to the wire post; a small brass eye is soldered to the edge of the keel to take the bottom end of the rudder post. The mast tube should allow the mast to rake, or lean, slightly to the after end of the boat.

The deck, after placing some putty along the top edge of the hull, can then be screwed in place with small wood screws placed about three inches apart. The hull is then ready for sand-papering and varnishing and painting. The deck should be varnished and the hull can be painted white above water-line and dark green or black below water. Two or three coats of varnish or paint should be given.

For the sails and rigging as few parts as possible should go to the make-up. The mast should stand 1 feet 9 inches above the deck, and should be ½ inch diameter at the deck to fit in the brass socket, and taper very slightly up to a point a little above the point where the gaff meets the mast, and from there up to the top tapering to ¼ inch. The boom is ⅜ inch diameter at ⅔ its length from the mast and tapers to ¼ inch at the ends. The gaff is 14 inches long and ¼ to $\frac{3}{16}$ in the middle and tapers slightly to the ends.

The bowsprit is 7 inches long and projects 3½ inches beyond the bow of the boat; it is ⅜ inch wide along the deck and ¼ inch thick, and the out-board end tapers to ¼ inch in width. A supply of small brass screw-eyes such as are used for hanging small pictures will be found useful for rigging the boat. At the in-board end of the boom, where it joins the mast, two screw-eyes are used; one is screwed into the end of the boom, and the other with the eye opened slightly so as to allow the other eye to be hooked under it, completes this fitting.

The yoke for the gaff can be made of brass wire or filed up from sheet brass $\frac{1}{16}$ inch thick, and the spiked end driven in the end of the gaff. A little shellac on the spike will help to hold it securely.

Travelers for the mainsail and jibsail can be made of brass wire bent to shape and with the ends flattened out and drilled for small screws and screwed to the deck, or two screw-eyes with a cord traveler and a ring for the sheet to pass through may be used. Cleats are made from strips of brass and drilled for small wood screws to screw onto the deck. Cleats are shown on the rigging plan (Fig. 8) at *C*, and screw-eyes at *E*.

For the sails cambric or the lightest cotton cloth should be used. Sewn or brass shoe eyelets can be used at the corners, and the mainsail laced to the boom and gaff with heavy thread and needle. Fitting loosely around the mast, and spaced equally along the luff of the mainsail and fastened to it, are 5 or 6 rings of brass wire, to keep the sail to the mast. Wire hooks are passed and bent through holes in masthead and end of bowsprit for the hoists, etc.

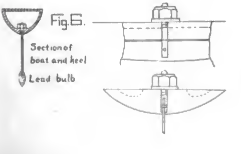


Fig. 6.

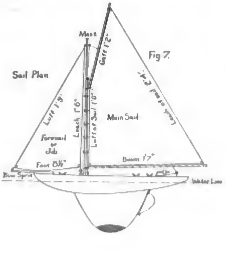


Fig 7.

Observations of the Afterglow

By B. Thieme

A PRELIMINARY communication describes briefly several new observations on the afterglow produced in the gas of a low-voltage carbon-filament lamp after a discharge has been passed, by placing it in an alternating field of high frequency (a Tesla field). The conclusion is that the afterglow is a periodic discharge occurring about 30 or 40 times per second, the period becoming smaller the longer the duration of the effect. Experiments on the discharge which occurs when the bulb of the lamp is electrified by friction are also described, with the conclusion again that the discharge is periodic. Further experiments are being made, on which the authors expect to report later.—*Verhandlungen der deutschen physikalischen Gesellschaft.*

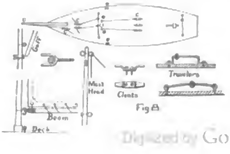


Fig 8

Discharge, Prickwillow.

Suction, Prickwillow.

Engine, Wisbech.

Suction at Wisbech.

Modern Pumping Machinery*

As Employed for Drainage of the Fens, England

By Richard W. Allen

The drainage of that large tract of low lands known as the Fenland (Lincolnshire, England), comprising over 450,000 acres, is generally but little understood. That the subject is full of interest, and the mechanical devices so varied, will be acknowledged, when it is mentioned that to-day the following methods are employed for carrying out this great work, without which the land would be entirely unproductive:

(*a*) Windmills driving scoop-wheels.

(*b*) Beam-engines (single and compound cylinder) driving scoop-wheels.

(*c*) Beam-engines and horizontal engines driving vertical-spindle pumps through gearing.

(*d*) Vertical steam-engines driving horizontal-spindle centrifugal pumps.

(*e*) Horizontal oil-engines driving horizontal-spindle centrifugal pumps.

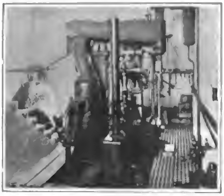
To describe in detail the mechanism under each of these headings would be quite beyond the scope of this paper, and the author therefore proposes to deal chiefly with those which are included under headings (*d*) and (*e*).

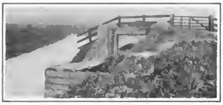
(*a*) *Windmills driving Scoop-wheels.*—This type of machinery is rapidly disappearing; the largest example now working is situated on the banks of the River Ouse at Harriermere, Middle Fen District, near Ely, the scoop-wheel being 30 feet in diameter with 5 feet by 14 inches ladles, Fig. 1. The dip of water on the ladle is 1 foot 9 inches and the maximum lift to which the wheel is capable of working is 10 feet. This mill has four sails, 40 feet long by 7 feet wide, and the ratio of gearing gives four revolutions of the sails to one of the scoop-wheel.

(*b*) *Beam-engines driving Scoop-wheels.*—This class of machinery is gradually being replaced by more modern pumping engines, due in many cases to the fact that the subsidence of the land has been so great, varying from ½ inch to 1 inch each year, that the present level of the various main drains is too low to allow sufficient dip on the ladles of the scoop-wheels.

(*c*) *Beam and horizontal Engines driving geared vertical-spindle Pumps.*—A difficulty now being experienced with many of the existing vertical-spindle pumps, is that, in order to charge the pumps, the water in the drains has to be raised to such a level that there is grave danger of some of the lowest lying land being flooded before the machinery can be set in operation. The cost of lowering the scoop-wheel or the pump, as the case may be, is such an expensive matter and the efficiency under the most favorable conditions so low, that it is more economical to remove the old plant and replace by more modern machinery.

(*d*) *Vertical Steam-engines driving horizontal-spindle centrifugal Pumps.*—During the past fifteen years a number of pumping plants have been installed, in the majority of cases new machinery included under clause (*d*) replacing existing appliances for raising water.


Engine House, Prickwillow.


Discharge, Soham Mere.

For purposes of illustration, the author has chosen some of the following stations in which he has been interested, representing some of the most recent work in the district; but, at the same time, he wishes it to be understood that there are many other stations, such as those erected at Lancham, Puddock Bridge, and in the North Level, which are doing excellent work:

I. Prickwillow, Middle Fen Commissioners.
II. Wisbech, Waldersea District Commissioners.
III. Soham Mere, Dunn Gardner Estate.
IV. Mr. Martin's Farm, Hilgay.
V. Ten-Mile River Bank, Littleport and Downham District.

Before describing the pumping stations in detail, it may be interesting to give in condensed form the main points to be considered in the design and construction of drainage machinery suitable to the conditions obtaining in this area:

(1) In the wettest season the machinery only works five to six months during the year, and in a dry season only three to four months, and sometimes less.

(2) Initial cost has to be kept as low as possible, as the Fen Commissioners have seriously to consider their drainage tax.

(3) Plant to be so designed as to run continuously for at least a month.

(4) The machinery will generally be run by a skilled laborer, not a mechanic. Simplicity is therefore essential.

(5) Water for boilers and for condensing purposes always contains a large percentage of mud in suspension, and this particularly so during the wettest time of the wet season.

(6) Efficiency to some extent must be sacrificed to initial cost and simplicity of design.

(7) Cost of maintenance and renewals must be reduced to a minimum.

(8) All calculations must be based upon amount of coal consumed to the water horse-power discharged.

(9) When new plant is installed, the old foundation must be utilized as far as possible.

(10) All new foundation work, unless well stepped into existing foundations, must be placed upon piled ground, or reinforced concrete employed.

(11) The maximum quantity of water has to be always discharged upon the highest lift.

These considerations have been met to a very large extent by the machinery installed at the stations already referred to, due especially to the fact that the centrifugal pump applies itself so well to differences in level of the water in the drain and river. The suction and discharge pipes of the centrifugal pump with a horizontal spindle are laid in the old race of the scoop-wheel with very little cutting away or filling in, and, by extending these pipes outside the building, little or no alteration is required to be made to the main walls of the engine-house. The foundations necessary for the engines are small and easily made in the original engine-house, and further, the

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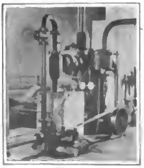
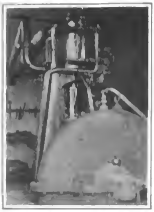
* Paper read at the Cambridge meeting of the Institution of Mechanical Engineers (England)


Engine room, Soham Mere.

Main drain, St. Martin's Farm.

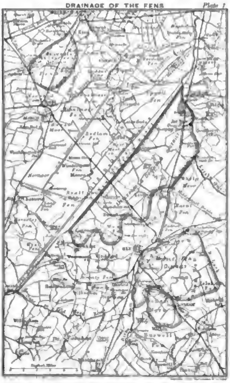

Engine and pump, St. Martin's Farm.

Suction, Soham Mere.

extra length of suction pipe can be readily added when required to meet any lowering of the main drain, due to subsidence of the land.

From experience gained, the machinery most suitable is that consisting of Lancashire boilers, vertical double-acting enclosed forced-lubrication engines running at a moderate speed driving direct centrifugal pumps with horizontal spindles, the condensing plant of the jet type having the injection water well strained before reaching the condenser, and the air-pumps driven either direct from engines or by gearing running in an oil-bath. It is upon these lines that these pumping stations have been designed, with the exception that engines of the open type have been supplied in place of those of the enclosed. This has been brought about by hesitation of the Fen Authorities to depart from the exceptionally low revolution engine, although in many cases the piston-speed of the enclosed engine proposed has been less than that of the open-type engine, yet permission to install the former has not so far been granted.

Water-tube boilers, steam-turbines and surface condensing plants have on occasions been suggested as an alternative, but the author ventures to think that their claim does not show sufficient merit to warrant their acceptance, as the slight gain, if any, in efficiency would not show sufficient return to cover the interest upon the increased initial capital expenditure; further, it might be necessary to duplicate the machinery to enable the cleaning of the boilers and condensers to be carried out efficiently; and, lastly, the unsuitability of the feed and cooling water for this class of machinery.



Map of the Fen District, Lincolnshire, England.

I. Prickwillow, Middle Fen District.—This pumping engine was installed in 1897 replacing a side-lever condensing engine of 60 nominal horse-power, erected in 1833, using steam at 6 pounds per square inch, and driving a scoop-wheel 33 feet 6 inches in diameter.

The machinery, Fig. 2, consists of a vertical compound double-acting condensing open engine, driving direct a horizontal centrifugal pump. The steam-cylinders are 21 inches and 35 inches diameter, each having a stroke of 1 foot 8 inches. The engine is capable of developing 300 indicated horse-power with steam-pressure at 75 pounds per square inch. The diameter of the suction and delivery pipes is 43 inches, and the pump is capable of delivering 150 tons of water per minute upon a 16-foot lift at 130 revolutions. The revolving disk is 5 feet 6 inches diameter, and is made of cast-iron and keyed to a steel shaft, running in white-metal bearings. The pump is provided with steam-ejector, for the purpose of charging. The engine has fixed on the high-pressure crosshead a connecting-rod with reciprocating beam, the levers of which are connected to a single-acting air-pump, 20 inches diameter by 10 inches stroke. Attached to the air-pump is a jet-condenser, giving a constant vacuum of 26–27 inches, steam being supplied by two Lancashire boilers, 23 feet 6 inches by 8 feet diameter, with Galloway cross-tubes.

Old beam engine, Ten Mile River Bank, Littleport.

Compound condensing engine and centrifugal pump installed in 1912.

Suction Discharge.

From March, 1912, to March, 1913, this engine ran on 209 days (of 12 hours duration), the maximum non-stop run being 372 hours during the latter part of August. The average coal consumption was 3½ tons for the 12 hours, including the raising of steam in boilers.

This district has a taxable area of 11,000 acres and about 25,000 acres to be drained, and to-day the drainage is mainly carried out by this pump, assisted by a 60 horse-power compound condensing beam-engine driving a vertical spindle pump, the engine being supplied with steam at 65 pounds pressure. The main drain is 30 feet wide and 7 feet deep at starting level, and there are about 30 miles of drains connected thereto.

The capacities of the old and new machinery may be of interest, and are tabulated below. It will be noted

Type of plant.	Date of erection.	Steam pressure.	Revolutions of engine.	Lift in feet.	Water lifted.
		lb. per sq. in.	per minute.	ft. in.	tons per minute.
Side-lever condensing engine driving scoop-wheel.....	1833	6	25.5	9 10¾	68.9
Vertical compound condensing marine engine direct-driving horizontal centrifugal case-pump............	1897	75	132	13 4	153 2
	1911	—	——	15 4	——

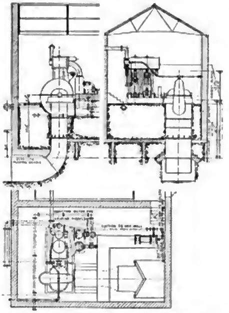


Fig. 2.—Middle Fen drainage commissioners Prickwillow pumping station.

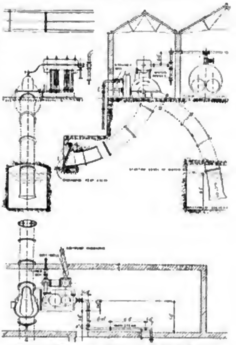


Fig. 3.—Waldersea drainage district Wisbech pumping station.

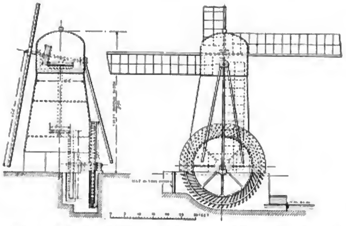


Fig. 1.—Windmill at Harrier Mere driving 30 feet diameter scoop-wheel. Middle Fen District.

that, owing to the subsidence of the land, the lift of the pump has increased in 16 years from 13 feet 4 inches to 15 feet, and in 80 years it has increased practically 6 feet.

II. Wisbech, Waldersea District Commissioners.—This machinery, Fig. 3, was erected in 1900. It consists of a vertical compound double-acting open engine driving direct a horizontal-spindle centrifugal pump. The engine has cylinders 18 and 29 inches diameter by 16 inches stroke, and is capable of developing 200 horse-power, when running at 130 revolutions per minute. It is supplied with steam at 90 pounds per square inch from two Lancashire boilers, 29 feet by 7 feet 6 inches diameter. The diameter of the suction and discharge pipes is 36 inches, and the pump is capable of discharging 100 tons of water per minute against a total lift of 15 feet, the diameter of the disk being 4 feet 6 inches. A jet-condenser is provided giving a constant vacuum of 26 to 27 inches. The air-pump, 16 inches diameter by 9 inches stroke, is worked from the high-pressure crosshead.

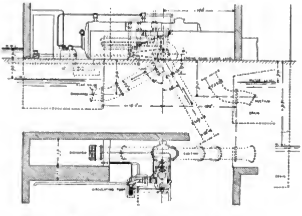


Fig. 4.—Soham Mere pumping station.

This district consists of 5,000 acres and its waters are discharged into the River Nene about 5 miles above Wisbech. It was originally drained by two engines, one erected in 1832, a Cornish beam-engine of 70 nominal horse-power working a bucket-pump 62 inches diameter with 7 feet 6 inches stroke, and the other erected in 1883, a single cylinder condensing engine driving a vertical-spindle centrifugal pump. The former plant was removed in 1900 and replaced by the machinery described above, the old well being used for the suction pipes of the pump. Practically no alteration was required to be made to the foundations or building.

III. Soham Mere, Dunn Gardner Estate.—This pumping plant, Fig. 4, was erected in 1910, and replaced an old beam-engine working with 10 pounds of steam, driving a 36-foot scoop-wheel. The engine is of the open compound type driving direct the centrifugal pump. The engine has cylinders 9 inches and 15 inches diameter by 9 inches stroke, and it is capable of developing 65 brake horse-power when running at 250 revolutions per minute, steam being supplied from a Lancashire boiler, 20 feet by 6 feet 3 inches diameter, at 120 pounds per square inch.

The diameter of the suction and delivery pipes is 22 inches and the pump is capable of delivering 35 tons of water per minute against a total lift of 17 feet. The condensing plant is of the ejector type capable of maintaining a vacuum of 26 inches. The injection water centrifugal pump is driven by belting from the main engine shaft, this water being carefully strained on the suction side.

The pump was placed in the old wheel-house and the suction and discharge pipes laid in the wheel race, no alteration whatever being made to the suction and delivery culverts. The engine stands in the old engine-house upon the old foundations, the foundation work being therefore reduced to a minimum. The coal burned is from 2½ to 3 tons in 24 hours. The main drain is about 20 feet wide and 6 feet deep at starting point, altogether 5 or 6 miles of drains connecting thereto, the discharge culvert being 6 feet by 4 feet 6 inches wide.

This district consists of about 2,000 acres and discharges its waters into Soham Lode about 4 miles above Ely. It was, as its name implies, an inland lake and was originally drained by windmills and the steam-driven scoop-wheel previously described. The strata of the soil consist of about 4 feet of silt, 3 to 4 feet of peat and then the clay. About 650 acres are held by small holders, the land, in quantities of 50 acres each holding, being let by the Cambridgeshire County Council.

IV. Martin's Farm, Hilgay.—This plant, erected in 1909, is one admirably suitable for landowners wishing to have, or compelled to have, their own drainage plant. It consists of an open double-acting single cylinder non-condensing engine driving direct a horizontal-spindle pump. The diameter of the cylinder is 10 inches with a 9-inch stroke, and when supplied with steam at 60 pounds pressure per square inch and running at 275 revolutions per minute is capable of developing 30 brake horse-power. The pump delivers 13½ tons of water per minute against a lift of 17 feet, the main suction and delivery pipes being 14 inches diameter. The end of the discharge pipe which is water sealed is fitted with a balanced flap valve to prevent siphoning back of the river water when the pump is not working. The boiler is 20 feet by 5 feet diameter.

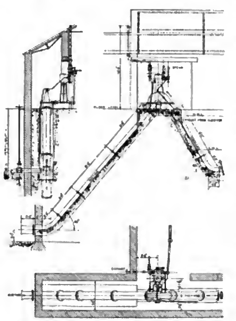


Fig. 5.—Mr. Martin's farm pumping station.

This estate, which is situated in Hilgay Fen, discharges its water into the River Ouse about 5 miles above Denver sluice. The area is 750 to 800 acres, and was formerly drained by a single-cylinder beam-engine driving a 34-foot diameter scoop-wheel. Beyond deepening the suction and discharge culverts for a short distance, and partially removing the division wall between the engine-house and wheel-house, no foundation work was necessary, the pump being placed on girders directly over the old wheel race. Fig. 5 shows the arrangement of this plant.

V. Littleport and Downham District, Ten-Mile River Bank Pumping Station.—This installation, which is one of the largest drainage stations in the Fens, was erected in 1912. It consists of two double-acting open compound condensing engines driving direct horizontal-spindle high-efficiency centrifugal pumps. The engines have cylinders 14 inches and 22 inches diameter by 13 inches stroke, and are each capable of developing 200 brake horse-power with steam at a pressure of 120 pounds per square inch.

The diameter of the suction and delivery pipes is 48 inches, and the ends of the discharges are fitted with multiple flap valves. Each pump is capable of delivering 150 tons of water per minute upon a lift of 15 feet, or 190 tons of water per minute upon 10 feet lift, when running at a speed of 210 to 220 revolutions per minute; each pump is fitted with outside bearings and steam-ejector for charging purposes.

The condensing plant is of the jet type, each engine driving, through gearing enclosed in an oil bath, twin air-pumps, which run at 90 revolutions per minute. The diameter of each barrel is 8¾ inches diameter by 11 inches stroke, and they maintain a constant vacuum of 26 inches. The injection water is drawn from the main discharge culvert, passing through a twin strainer which can be cleaned without causing any cessation in the flow of the water. The air-pumps discharge into a hot-well, from which the feed-pumps draw their water. Steam is supplied by three Lancashire boilers, 25 feet by 7 feet 3 inches diameter, the feed water having its temperature raised by means of a live-steam heater. The pumping machinery, Fig. 6, is so arranged that each unit is quite independent of the other.

The following records of the working of these pumps have been kindly supplied by the officer of this district:

From October 30th, 1912, to April 9th, 1913, the total hours of running were 1,458. Total fuel consumed, 600 tons. Total average lift, 11 feet 8 inches. Total water discharged, approximately, 170 to 180 tons per minute. The main drain is about 23 feet wide, and in all approximately 26 miles of drains connect thereto. At starting point of pumping there is 6 feet of water in the drain, and at stopping it is lowered to about 2 feet.

This district has a taxable area of 26,000 acres, but a total area to be drained of 35,000 acres, which was originally carried out entirely by windmills. At present the whole area is drained by two pumping stations, 7 miles apart, one at the Hundred Foot River and the other at the Ten-Mile River. The first steam plant erected in the district was a 30 horse-power engine and scoop-wheel at the Ten-Mile River in 1818.

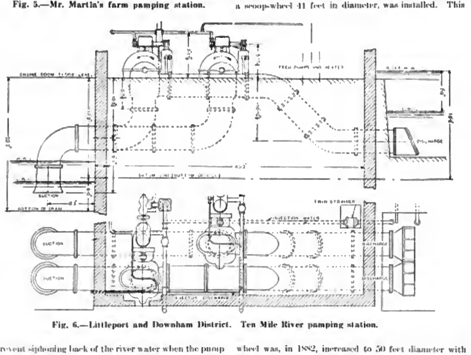


Fig. 6.—Littleport and Downham District. Ten Mile River pumping station.

In 1829 an 80 horse-power beam-engine, having a cylinder 3 feet 6 inches diameter by 8 feet stroke driving a scoop-wheel 41 feet in diameter, was installed. This wheel was, in 1882, increased to 50 feet diameter with 60 ladles, 8 feet long by 3 feet wide, and is working to-day. At the Ten-Mile River Bank Station, in 1843, the original steam-plant was removed, and an 80 horse-power condensing beam-engine was erected driving a scoop-wheel of 42 feet 8 inches diameter, which was increased to 43 feet 8 inches diameter in 1880. The wheel had 50 scoops 7 feet 6 inches radial length by 3 feet wide, and made 4¼ revolutions per minute, the gearing being 7 of engine to 1 of wheel, and at that date had an average dip of the scoops of 3 feet. Owing to the subsidence of the land, this dip was gradually lowered to 1 foot 10 inches, and in 1912 this plant was removed, and the centrifugal pumps previously described were installed.

The rainfall recorded in this district since the year 1901 is as follows:

1901	14.81 inches.	1907	20.23 inches.
1902	17.86 "	1908	16.16 "
1903	27.65 "	1909	25.38 "
1904	16.85 "	1910	21.85 "
1905	18.87 "	1911	20.65 "
1906	21.32 "	1912	31.01 "

(*c*) *Horizontal Oil-engines driving horizontal-spindle Centrifugal Pumps.*—This class of machinery has been installed especially for small plants in several districts, the first to be erected being at Denver Parts in 1897, and consisting of a 9 brake horse-power oil-engine driving an 11-inch centrifugal pump. Mention should also be made of a 24-inch pump driven by a 40 brake horse-power oil-engine in the March Third district, and an 18-inch pump driven by a 40 brake horse-power engine at Willingham. The author understands that a plant capable of delivering 100 tons of water per minute has just been installed in the Methwold and Feltwell district. This type of machinery has not, however, met with as much support from the Fen Commissioners as was at one time anticipated, the efficiency for plants of large capacity having yet to be determined and the danger of fire being points which may have been the cause of the slowness of development in this direction. The interior and exterior of some of the pumping stations referred to are shown in the accompanying photographs in the hope that they may be of some interest.

In conclusion, the author ventures to express the opinion that at no time has the problem of efficient drainage of low lands been of more importance than it is to-day. The abnormal rainfall of 1912, and the amount of damage done to so many thousands of acres, has brought this important question more prominently before the Drainage Commissioners of the whole Fen District. That it is necessary to drain these lands more efficiently may be due to the increased difficulty of getting rid of the water owing to the constant subsidence of the land, and also to the fact that to-day a different class of produce is grown, in many cases vegetables of various kinds, in place of cereals. That pumping machinery of larger power and capacity are being installed is evident, but at the same time it is quite as essential that the drains leading to these pumps should be deepened and widened so that the water can reach them easily, as unless this is done the maximum efficiency of the pumping plants can never be obtained.

The Cost and the Advantages of Using Electrically Melted Ferromanganese*

Electric steel furnaces of various types have found a new field of application in recent years, as they are being widely used in Europe to keep a molten supply of ferromanganese on hand at the converter plant. The use of molten ferromanganese instead of solid ferromanganese not only results in a saving of alloy, but makes the deoxidation more efficient and the steel better; and the cost of melting the ferromanganese electrically is more than counterbalanced by these advantages.

This method has been widely introduced during the last few years in Europe. The first plant to take up this practice in this country has been the Illinois Steel Company, which at its converter plant at Joliet, Ill., employs a 4-ton Heroult furnace to keep on hand a supply of molten ferromanganese from which 150 pounds are taken every seven minutes. It is the experience of this company that besides the saving in alloy there is a clear advantage in quality, the soft steel produced being decidedly better for wire purposes.

In Europe various types of electric furnaces have been employed for the same purpose, and the induction furnace has found particular favor in several plants. As very few exact figures have been published in the past on this subject, the following results obtained in three European plants employing induction furnaces for melting ferromanganese should be of timely interest:

The three plants in question use for this purpose a 3-ton, 250-kilowatt furnace, a 4-ton, 500-kilowatt furnace, and a 4-ton, 500-kilowatt furnace respectively, all being of the 3-phase, 50-period, 3-ring Roechling-Rodenhauser type, the design of which is very well known to our readers.

In the plant using the 3-ton, 350-kilowatt ferromanganese-melting furnace, some 30 to 50 tappings, ranging each from 90 to 120 kilogrammes (198 to 264 pounds), are made every 24 hours, depending upon the demands of the steel plant. For the first five weeks the average energy consumption, excluding the energy required for burning in the lining, was 721 kilowatt-hours per ton for an output of 220 tons of ferromanganese.

To maintain the furnace hot during long intermissions 200 to 250 kilowatts are required.

As a result of using molten ferromanganese, an average saving of 30 to 40 per cent of weight of ferromanganese required is recorded. With cold ferromanganese from 7 to 8 kilogrammes are used per ton of steel, and during a year some 2,100 tons of cold ferromanganese are required. With molten ferromanganese this amount is reduced to less than 1,400 tons, representing a saving of more than 700 tons, which at $55 per ton represents a saving of $38,500 per year.

In one of the plants with a 4-ton, 500-kilowatt furnace ferromanganese has been melted at the rate of 10 tons per 24 hours with an energy consumption of 750 kilowatt-hours per ton. The furnace, however, is capable of melting a considerably higher tonnage of ferromanganese per day, and when the demand of the steel works increases it may be expected that the specific energy consumption will be reduced.

At the same time the amount of ferromanganese used per ton of steel has been reduced at this plant from 7.5 or 8 kilogrammes (for cold metal) to 4 kilogrammes (for molten metal), which is a saving of from 45 to 50 per cent.

If the results of these two furnaces are used on which to base an estimate of the power requirement and savings to be expected in new installations, it seems safe to figure on a saving of 30 per cent in weight of ferromanganese and a power consumption of 675 kilowatt-hours per metric ton of ferromanganese for a 3-ton furnace in regular operation. For burning in the lining and heating up a 3-ton furnace about 3,500 kilowatt-hours are required, and a life of 12 weeks, or 84 days of 24 hours, may be expected for the lining. From these data a figure for an additional small power consumption may be deduced. As stated, all these figures refer to induction furnaces. It would be interesting to get for comparison data from arc-furnace installations.

Electric furnace for melting ferromanganese at Krupp plant.

The use of molten ferromanganese has, however, additional advantages which cannot be stated as easily in figures. Owing to the rapidity with which molten ferromanganese becomes distributed through a steel charge, much time is saved owing to the fact that the steel may be teemed at once. Further, low-grade ferromanganese, containing large percentages of fines, may be easily melted in an electric induction furnace.

That the quality of the steel is improved by the use of molten ferromanganese will be understood from the following considerations:

The deoxidizing effect is much stronger and more rapid than with solid ferromanganese, as the latter must first be dissolved and exerts a certain cooling effect.

As the ferromanganese is added to the steel while teeming, it does not come into contact with the slag, and rephosphorization by reduction of the phosphates in the slag is entirely excluded.

Frequent analyses in the three induction furnace installations in question have proved that the composition of the steel remains constant from the first to the last ingot for any one charge.

On account of the uniformity of the composition of each ingot, due to the better distribution of manganese and also to the more complete deoxidation, the steel "rolls" extremely well. It has been proven that a section which, when cold ferromanganese was used, could not be satisfactorily rolled with steel containing less than 0.4 per cent Mn, can, when molten ferromanganese is used, be rolled easily from steel containing only 0.29 per cent Mn.

The amount of ferromanganese per ton of steel can be considerably reduced on account of the certainty that the total amount of ferromanganese added is utilized and nothing is retained in the slag or remains undissolved in the steel.

The contents of the ladle can be poured at once, whereas much time is saved, and, moreover, the charge need not be so hot from start so as to be able to heat the ferromanganese to melting temperature. The liquid steel remains completely quiet, does not boil, and can be poured very satisfactorily.

The lining is put into ferromanganese induction furnaces in about the same way as in steel furnaces; that is, a mixture of magnesite, or dolomite, with tar is rammed in hot. But because the temperature required is not so high as for steel, and also because ferromanganese is usually in particularly convenient form for melting in an induction furnace, the life of the lining is much prolonged. From the results so far obtained it is thought possible when working continuously to average between four and five renewals per year, or even better.

No slag is required. The molten metal is effectively protected from oxidation by a layer of carbon in the form of petroleum coke. The metal being saturated with carbon, no alteration in composition occurs. The fact that such a covering is used proves that the atmosphere in the furnace is non-oxidizing.

While, as stated before, the Roechling-Rodenhauser type of combination induction furnace is used in the three installations here discussed, the Siemens & Halske Company, which made these installations, has developed more recently an improved type of induction furnace which combines the good points of the Kjellin, Roechling-Rodenhauser, and Frick types, and with which it has been possible to reduce the specific energy consumption still further.

While the data given above from European practice refer to plants using induction furnaces for melting ferromanganese, other types of electric furnaces are also used for this purpose in Europe. The adjoining illustrations show a 5-ton Girod furnace recently installed by the Friedrich Krupp A. G., Friedrich-Alfred Hütte, Rheinhausen-Friemersheim, Germany, for the melting of ferromanganese.

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* Reproduced from *Metallurgical and Chemical Engineering.*

The "Day of Rest" and Human Efficiency.

The refreshing influence of the weekly "day of rest" on a person subjected to the strenuous routine of a busy life is a feature which he himself can duly appreciate in the effects on his "feelings" and "spirits." The efficiency of the working-man, the length of the working-day, the interjection of pauses for rest in the schedule of labor for persons of different ages and stations in life—questions of this sort are constantly arising for solution on a scientific basis. Not only in the field of manual labor, but also in the case of the schoolchild, the office-boy, the factory-girl, the banker and the merchant, efficiency is the key-note of the times.

In view of this, says *The Journal of the American Medical Association*, it is of more than passing interest to know that Dr. Martin and some of his associates in the Laboratory of Physiology at the Harvard Medical School, have been making a careful study of the whole question of fatigue and efficiency from a physiological standpoint. A long series of experiments have been made on first-year medical students who were following a regular routine of school work during six days of each week. The routine was interrupted weekly by the Sunday recess, an interval occupied variously by the students, but in no case in precisely the manner of the week days. The daily observations made on these persons during several weeks show that at the beginning of the week the nerve reaction tends to be high, that from then until the end of the week there is a fairly continuous decline, and that following the interruption of the routine by the intervention of Sunday, it returns to the original high point.

The decline is interpreted as a cumulative result of general fatigue incident to routine. What is even more significant, however, is the added fact that a pronounced break in the routine—such as the "day of rest" occasions—may bring about a return of sensitiveness to a high point or, in other words, it restores the nervous tone. Studies continued in this direction should lead to some useful conclusions regarding the maximum of work, with respect to both its duration and type, that should determine the conditions under which the organism of man may be maintained without depletion.

Safety at Sea

Provisions for Averting Loss of Life

The development of our great passenger steamers in point of size, speed and luxuriousness, has for many years past followed an upward curve, the crest of which has not yet been reached. Unfortunately a parallel progress in the matter of safety cannot be recorded. In fact, in one sense, it might be said that dangers of sea traveling have increased. For the larger the boat, the greater is apt to be the list of casualties in case of serious accident. This is not a mere academic argument, but a truth only too plainly demonstrated by the events of the past few years. Tragedies like those of the "Slocum" disaster, the sinking of the "Titanic," and quite recently, of the "Empress of Ireland," leave indelible memories in people's minds—a psychological effect upon millions of people. It is well that this should be so; it is merely one expression of the natural instinct which bids us profit by experience. But to what extent can this instinct be said to have worked effectively in the matter of safety at sea? Recent events hardly seem to warrant any optimistic view on this point. True, the very fact that disaster has followed so close upon disaster has given naval constructors little chance to make any material advances. It can hardly be expected that a large number of existing ships be radically reconstructed to meet the requirements, now recognized, of the maximum attainable degree of safety. Yet there are indications that the lesson of the "Titanic" has not yet been fully assimilated, and it seems to have required this renewed disaster to force home the necessity of the double skin in those great steamers that carry thousands of passengers.

There can be no doubt that the chief attention of the naval constructor, as regards provision for safety of travel, must be concentrated upon the prevention of disaster, rather than upon those poor last resources, lifeboats, etc., which have proved so inadequate in all great shipwrecks.

Nevertheless it will never be possible to dispense entirely with these accessories, and efforts to make them as perfect as possible are entirely in order. The provision of various substitutes or partial substitutes for the customary lifeboats has been suggested. The motor-driven lifeboat commends itself as a modern improvement, but has not yet proven its worth. Moreover, its use is presumably limited, since it is hardly likely that all a ship's lifeboats can ever be thus equipped. Rafts of various kinds have been suggested and actually installed. Soon after the "Titanic" disaster, we published a description of a "floating deck," which should be released from the body of the ship in case of the latter's sinking, and which should remain afloat and provide a safe refuge for the passengers and crew until they were taken off by some rescuing vessel.

That there is merit in the proposal, and that it can be practically applied, is shown by the fact that the Pollok prize for the best method of saving life at sea was awarded to a design in which the whole of the bridge structure was so built that it would float independently of the vessel.

It has been suggested that, in the case of a ship like the "Titanic," the large deck houses on the boat deck might be built upon this principle and so arranged that they could either be launched from special launching ways, or permitted to float free when they become sufficiently submerged to assert their buoyancy.

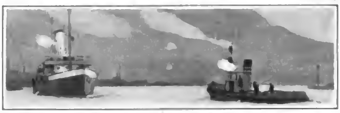
The objections to this arrangement are: First, that such structures would be too heavy to be launched in an emergency with any certainty of safe and successful operation; and secondly, that if the pontoons were left to float of themselves as the ship went down, they would be liable to become entangled with the smoke-stacks and their heavy steel guy ropes and either upset or seriously damaged. In nine cases out of ten, the damage to ships is received forward of midships, and the vessel sinks by the head. Evidently, then, the best location for the pontoon structure would be at the stern of the ship, and preferably on the quarter deck.

We reproduce, from an earlier issue of the Scientific American, on our front page, the outlines of a design in which the upper decks of the after portion of the ship, astern of the midship structure, are utilized for this purpose. In the design shown, the pontoon extends for a depth of two decks, covers the full width of the ship, and reaches from the midship superstructure to the after-rail. For full security, and to provide the necessary stiffness, it might be built with a shallow double bottom. The outside hull plating might be carried down until it lapped, with ample clearance, an inch or so over the plating of the ship itself—an arrangement which would conceal the fact that the pontoon was a separate structure and would give it the appearance of being an integral part of the ship itself.

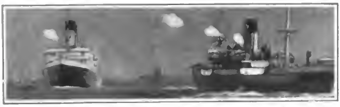
The problem of securing this pontoon in place would not be so difficult as might be supposed. It could be done

Whistle-blast signals and their meanings.

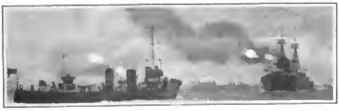
Drawn by Cecil King, R.B.A.



One short blast.—"I am directing my course to starboard." The two vessels are approaching end on; each is going slightly to starboard, and they will pass to port.



Three short blasts.—"My engines are going full speed astern." The vessel on the left has the right of way, and is holding on and going slightly to starboard (one blast); that on the right is going full speed astern. (Compare also the illustration opposite.)



Two short blasts.—"I am directing my course to port." The battle-cruiser is coming out of harbor and crossing over to port; the destroyer is going to port also.

Two long blasts.—Blown in thick weather by a vessel under way but stopped, and having no way upon her.

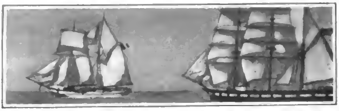
Lights and the rule of the road for ships.

"Green to green and red to red;
Perfect safety—go ahead."

Each ship is showing the other her port light.

"If to your starboard red appear
It is your duty to keep clear . . . .
If green to port there's nought to do,
For green to port keeps clear of you."

The left-hand ship shows a green light, but sees the red light of the right-hand ship on her starboard hand. The former must therefore give way.



Sailing.—A ship close-hauled on the port tack gives way to one close-hauled on the starboard tack. Here the right-hand ship gives way.

A steamer always gives way to a sailing ship, whatever her course.

in several ways. As a suggestion, the deck on which it rested might be provided with several longitudinal rib-like projections which would register with corresponding longitudinal recesses, sunk in the outer shell of the double bottom of the pontoon. Both the ribs and the recesses would be tapered in cross section, and both would be provided with bearing strips of bronze or other non-corrodible metal, so as to insure the ready release of the pontoon when the ship went down. These ribs would effectually hold the great weight of the pontoon against lateral movement when the ship was rolling, and the friction of the ribs would be sufficient to prevent longitudinal movement under the much smaller fore-and-aft forces set up by the pitching of the vessel.

If it were deemed necessary, a few holding-down bolts, readily accessible and quickly released, might be added as a further precaution. A double-deck pontoon, with its deck houses of the size shown in our front page engraving, would be sufficient to accommodate, in an emergency, the whole of the passengers and crew of one of our modern leviathans.

In connection with the collision between the "Empress of Ireland" and the "Storstad" questions of right of way at sea and methods of signaling, especially at close quarters and in fog, have been brought before public attention. The accompanying illustrations, for which we are indebted to the *Illustrated London News*, show graphically some of the signals by whistle or siren, and also some of the ships' light signals referred to at the inquest at Rimousky. Capt. Kendall in his evidence said: "I blew three short blasts on the steamer's whistle, meaning, 'I am going full-speed astern.' After that he answered me with his whistle, giving one prolonged blast. I then looked over the side of my ship into the water and saw that my ship was stopped. I stopped the engines and blew two long blasts, meaning that my ship was under way, but had stopped and had no way upon her. . . ." With regard to the last signal, it may be noted that in the Regulations for Preventing Collisions at Sea is the notice: "A vessel is 'under way' within the meaning of these Rules, when she is not at anchor, or made fast to the shore or ground." It is prescribed that steam-vessels shall give sound signals on the whistle or siren. The words "prolonged blast" mean a blast of from four to six second's duration. The words "short blast" mean a blast of about one second's duration.

In the statement made for the captain of the "Storstad," it is said: "The vessels sighted one another when far apart. The 'Empress of Ireland' was seen off the port bow of the 'Storstad.' The green (starboard) light of the 'Empress of Ireland' was visible to those on board the 'Storstad.' Under these circumstances the rules of navigation gave to the 'Storstad' the right of way. The heading of the 'Empress of Ireland' was then changed. . . . Shortly after, the fog enveloped first the 'Empress of Ireland' and then the 'Storstad.' . . . The 'Empress of Ireland' was then seen through the fog close at hand on the port bow of the 'Storstad.' She was showing a green light and making considerable headway." A regulation of the sea says: "When two steam vessels are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other."

The Future of the Submarine

KEEN interest has been reawakened in England in the subject of the relative importance of the submarine-boat and the battleship by the publication in the London *Times* of a letter from Admiral Sir Percy Scott, because this distinguished naval officer has taken the view that the "building of any more battleships now will be a misuse of money subscribed by the citizens for the defence of the Empire," as he can see "no use for battleships and very little chance of much employment for fast cruisers." Commenting upon this, our British contemporary *Engineering* remarks: "For a long time it has been recognized that the submarine-boat must take an increasingly important part in war tactics, and there is no doubt that in those peace maneuvers where war conditions are simulated the submarine-boat has taken a place of growing significance and success. But the storm of criticism which Sir Percy has raised in the columns of our contemporary shows that the change he advocates now must be of gradual growth, and not a *volte-face*, and that the acceptance of his view, as quoted, would be a grave danger to the defence of the empire. It certainly cannot be said that he has adduced convincing reasons for the complete change in naval policy which he advocates.

"His view is that at the beginning of hostilities submarine-boats will be able effectually to bottle up in harbors all surface craft, and that a 'battleship is not immune from attack even in a closed harbor, for the so-called protecting boom at the entrance can easily be blown away.' Thus, if a battleship is not safe on the high seas or in harbor, he asks: 'What is the use of a battleship?' Moreover, he says, submarine-boats are difficult to destroy, because 'it is difficult to attack what you cannot see.' Thus he contends that what we require is an enormous fleet of submarines, airships and aeroplanes, and a few fast cruisers, provided we can find a place to keep the latter in safety during war time. We are at one with Sir Percy Scott in his view that we should have a great fleet of submarine-boats, but until other powers decide to cease building battleships and other surface craft, it would be fatal for Britain to discontinue the present policy so far as these are concerned. A 'Naval Officer,' who has written most cogently on the weaknesses of Sir Percy Scott's contention that we must cease building battleships, controverts the premise on which Sir Percy founds his conclusion. The booms protecting harbors have never been destroyed by submarine-boats, and although torpedo-boat destroyers have been able to enter harbors thus protected, they have done so by 'jumping the boom,' with considerable damage to themselves. Moreover, if the enemy's surface ships succeeded in escaping from harbor, there would be serious menace to Britain, and particularly to our food supply, in consequence of the depredations which they might effect when unopposed by vessels of equal modernity and corresponding speed. No doubt for a few years our present surface boats would equal in tactical quality those of the enemy. But if, at Sir Percy Scott's injunction, we ceased building such vessels, while other powers continued to do so, we should be placed in jeopardy in a very short time. It may not be easy to fight submarine-boats except by their opposites; but by reason of their comparatively low speed, they would never overtake a surface boat which might escape from harbor. Besides, it has not been established by Sir Percy Scott that the torpedo, practically the only weapon of the submarine-boat, would be effective. Again, the radius of action of such boats when submerged is very limited, not much more than 100 miles, so that in taking a voyage across the North Sea they would have to proceed 'awash,' and would then be subject to attack by torpedo-boat destroyers and other surface craft, and by aerial vessels.

"Our intention in discussing this matter is not so much to consider the tactical qualities, but to regard the problem of the future potentialities of the submarine-boat from a mechanical standpoint. Until such craft are made more powerful, are given a higher speed, and have a much greater radius of action, their success must be limited, even in attacking vessels in harbor, particularly in the presence of the latest system of submarine-mine defence. All of these qualities call for increased dimensions, which increase their cost and reduce their handiness, especially in harbors and comparatively shallow waters. That progress is being made in the design of submarine-boats to attain the advantages desiderated is undoubted. The British Admiralty are fully alive to the possibilities of this new type of craft. They are vigilant in their study of progress in other navies, and are acting with enterprise in the encouragement of developments, particularly in respect of propelling machinery and torpedo design. The interests of the nation preclude us from giving information regarding the latest British experimental vessels, but it may be said that in the one case the size exceeds that of any submarine-boat yet ordered, and that in another case the aim is for higher speed. When these two vessels are completed their trials will disclose to the technical officers of the admiralty the lines along which further development may be made.

"First, in regard to size, it may be said that the largest of the German boats nearing completion has a displacement on the surface of 750 metric tons, and submerged of 900 tons, the length being just over 214 feet. It is propelled by two sets of Diesel engines, together of 4,000 brake horse-power, working twin screws, and it is anticipated that the speed on the surface will be about 20 knots, and submerged about 10 knots. Russia is understood to be building a vessel of considerably over 1,000 tons, and proposals for ships of as much as 1,700 and 2,000 tons displacement are being considered by other powers. These larger vessels will be able, of course, to carry a greater offensive armament, either by increasing the number of torpedoes, or by fitting larger guns with disappearing carriages, for which cavities are formed in the deck. It is understood that, so far, only 12-pounder guns are contemplated. If, however, four guns of 4-inch caliber were adopted, the displacement would require to be increased, while the adoption of 6-inch guns would necessitate an increase in displacement of 18 per cent over the vessel with 12-pounder guns. Increase in size, too, demands greater power, even if the speed be constant, and the aim is to get still higher speeds. So far practically all modern submarines are propelled by heavy-oil engines, and little difficulty need be experienced in supplying to a submarine-boat engines of 4,000 or 6,000 horse-power without increasing to any appreciable extent the size of the individual cylinder. Moreover, progress has undoubtedly been made in the reliability of engines with cylinders of much higher power, and one may anticipate in the early future cylinders of 1,000 horse-power. No trouble need be anticipated on this score excepting that the size of the ship must go on increasing if higher speeds are desired than are at present anticipated.

"There is, however, a growing disposition to experiment with steam-turbines in submarine-boats, and it will be remembered that France many years ago adopted a flash boiler for developing steam for driving submarine-boats, but the results were such that the system was discontinued, largely because of the time required to damp down the boiler preparatory to diving. With the perfection of oil fuel-burning apparatus for water-tube boilers, and the great gain in the introduction of the steam-turbine, opinion in France has undergone a change, and at the present time there are being built a large number of submarine-boats, with express boilers of the Yarrow type, having specially small tubes, in order that the water contents may be less than is the case even with destroyers. The turbines are of the Parsons type, to run at very high speed, gearing being introduced between the turbines and propellers. The four submarine-boats of this type most advanced are those built at Rochefort, of 900 tons displacement, and with turbines to give 4,000 shaft horse-power, namely, 2,000 on each shaft. Two others are building at Cherbourg, and in this case the displacement is 950 tons, the power being 5,000 shaft horse-power. There will be electric motors for propulsion when submerged, as in existing vessels. It is understood that even larger steam-driven submarines are about to be laid down, the power of the turbine machinery being 10,000 shaft horse-power, and the speed anticipated over 20 knots. It is under consideration in this latter case to fit, for low-speed running, oil engines for cruising on the surface. This would conserve the oil-fuel supply, as the oil engine has a less consumption than the steam installation. Thus the radius of action at cruising speed would be very greatly increased. It is a case of balancing advantages and disadvantages from the weight point of view. It remains to be seen whether the oil engines for cruising at low speed would save, under given strategic conditions, an amount of fuel corresponding to the excess consumption at low speed of the steam engine, and thus compensate for the weight of the oil engine, which must be dead-load when running at full speed. But there still remains the fact that greater power of offensive, higher speed, and wider radius of action—all necessities of the case—involve increase in size.

"Every increase in the size of a submarine-boat not only adds to its visibility when running awash, but increases the time and distance required for disappearing if the vessel has to dive, and not to sink on an even keel, unless the angle at which the vessel dives is made much steeper. The difficulty in such case has reference to the electric storage batteries, and to other vessels containing liquids, where alterations in the level introduce disturbing influences. The acuteness of the angle of dive, too, intensifies the difficulty of subsequently bringing the vessel to an even keel, and increases the danger of the vessel striking the bottom, a danger which has involved the loss of one or two submarine-boats of comparatively small size. Greater depth of water is required for such operations, so that only small vessels can be used in attacking ships in harbor.

"These various developments in the mechanics of the submarine show that progress is being made, but the problems have so many variants and demand such careful research that it would be a mistake to hasten unduly those responsible for the evolution of design. What is demanded on the part of our naval authorities is to move with as much rapidity toward improvement as is consistent with the insurance of reliability in each vessel built, and at the same time to maintain as much secrecy as possible. From the mechanical point of view the submarine is undoubtedly in a transitory state. To accept any design at the moment, and build a great number of vessels in excess of the requirements as measured by our opposing forces, would be unduly to tax the citizens' responsibility for the defence of the empire, with the extreme probability that the vessels thus built would be obsolete in a very short time. For this reason we advocate an active policy by the admiralty, but would regard as a tactical blunder the neglecting of the building of ships-of-the-line, particularly when all other powers are continuing to add to their fleets battleships and cruisers."

Hyndman Peak, Idaho, the highest named peak in the State, is more than 12,000 feet high. Several unnamed peaks near it are of about the same elevation. All are on the divide between the Sawtooth and **the Lemhi national forests.**

How the Ancients Would Have Controlled the Mississippi and Its Tributaries*

By Sir William Willcocks, Cairo, Egypt

When I went to South Africa for the British government about ten years ago I remember being asked to address a number of Boer farmers on the question of rust, which had attacked their wheat crops. After describing to them how the Egyptians had for 7,000 years sown wheat and leguminous crops in rotation, and at the end of those 7,000 years had their land as rich as it was when they first began, while the Boers in 50 years by growing cereals only had made their land so poor they could scarcely get anything to grow on it, I thought I had made an impression on those people; but when I had finished, the chairman said to me: "Now don't talk to us about those exploded old world theories of rotation of crops. We young people have altogether grown out of that." My discourse on that occasion was fruitless. I hope for different things from you.

With your permission I am going to tell you how I think the ancients would have controlled the Mississippi River and the flood problems you have in this country. The problems on the Mississippi are harder than those on the Nile. They are like those on the Euphrates, but the Tigris is more difficult. In Egypt they began reclaiming the delta from upstream downward. When they had reclaimed a certain part they let the water flow on and reclaimed another, and so on. That was a simple problem. On the Euphrates and Tigris they began from the mouth upward, as you have done on the Mississippi.

I find that the Mississippi is about four times the size of the Nile, seven times the size of the Tigris, and twelve times the size of the Euphrates. But size in these questions has nothing to do with difficulty. Indeed, I have always found in any problems I have had to do with, that the bigger the problem the more easy it was to solve. You can see a big problem so clearly and its difficulties lie patent. I have always considered that a thing like the Assuan dam with 180 openings is less of a problem than a dam or a bridge with only one opening, because if one fails, and you have only one, the whole thing fails; but if you have 180 and one or two fail you have still 178. And to bring it home to all of us, I am sure there is not a single married man among us who does not know that Solomon with his 300 wives had a much easier problem than any of us has with his one wife.

The ancients were always very much in earnest with their rivers, far more so than you are here. In this country the lands likely to be inundated by the rivers lie here and there scattered over the face of the country. But in Egypt and ancient Babylonia they had nothing but what was irrigated by their rivers and able to be inundated by them. Everything else was desert. Imagine for an instant the Senators and Representatives in Washington sitting down and looking academically at the question of the Mississippi River levees, if the Capitol itself were located behind one of the levees of the Yazoo basin. Or imagine, as you have here, the commission which looks after the Mississippi levees taking care to locate itself well up at St. Louis, where it is totally out of danger. In Babylonia we should have made them all live behind the worst of their levees, and whatever else they did they would not have had any breaches. I believe you call them crevasses; we call them breaches. Accidents happened on the Mississippi in 1912 and millions of acres were inundated, 4,000,000—the whole of Egypt is only 6,000,000—and little thought was taken of it in this country. In the seventh century of our era a very serious breach occurred in the Tigris levee, and the King on that occasion threw 400 engineers and supervisors into the breach.

In 1887, when we had our last very high flood on the Nile, I saw a white-haired man going about his work very energetically, and I said to him, "I have never seen an old man as energetic as you." He said, "I am not old, only my hair is gray." I said, "How did it become gray?" He said, "I had charge of the Nile bank in the great breach of 1878. When it occurred the Khedive telegraphed to throw the engineer into the breach. I was that unfortunate man. They did not throw me in because the telegram arrived at evening, and they said they would do it at daybreak. My wife and other members of my family went up on special train to implore the Khedive to let me off. And in the morning I found that my hair had grown absolutely gray."

The Mississippi has been reclaimed, unfortunately for itself, from the mouth up. Louisiana made for itself fields and gardens behind its levees. When the next State farther up the river made its levees and concentrated the flow, it put Louisiana into difficulties. Louisiana raised its levees, and then it went easier until the next State up stream started to build levees. And however hard Louisiana works, it can barely keep ahead of the difficulties brought on it.

That is exactly what happened in Noah's flood. There was no Noah's flood in Egypt, because in making their river control works, they came down with the river. On the Euphrates they traveled up, and it was a very large dike thrown up to protect some upper basin which threw the whole waters of the river on those lower down, which produced the catastrophe known as Noah's flood.

The Mississippi from Cairo to the sea has a length of 1,000 miles; in a straight line it is 550 miles, and the width of the valley is about 50 miles. The fall in flood is 320 feet and in low water 270 feet; 1,540 miles of levees are along its banks. (In Egypt we have about 900 miles of levees.) The salient points, where the Mississippi bends from side to side, need protection and cover 400 miles. The *natural reservoirs* in the Mississippi Valley, which I shall call *basins* to distinguish them from reservoirs which are proposed in the hills, cover a very large area. The St. Francis basin with 4,000,000 acres, the Yazoo with 4,000,000, the Tensas with 3,000,000, and smaller reservoirs on the sides, bring the total above the Red River to 12,500,000 acres. Down stream from the Red River are 6,500,000 acres. These give altogether 19,000,000 acres of natural reservoirs.

Like all deltaic river valleys, that of the Mississippi is highest near the river bank, and slopes away to the hills on either side. In places the water at the bank is 30 feet higher than at the hills, so that when the water makes a breach it has plenty of land to go over, and finds it very easy to get away. Then this river, like all deltaic rivers, brings down a great deal of sediment. But the river soon begins to drop this into its bed, and then cuts out from the sides at the bends. Low down in its course nearly the whole of the sediment in the river is that which the river itself is cutting from its own banks.

Allowing six feet of water above the natural bank of the river, which is where the flood of 1862 came to, I calculate that these natural basins, or reservoirs, in the Mississippi Valley itself represent about 12,500,000 acres, eight feet deep, or 100,000,000 acre feet. I have put these figures into acre feet because left in cubic feet they run into nine or ten naughts, which represent things we do not understand.

Now if the ancients had had this river, they would have considered these reservoirs as a great asset, and never would have used them or let them be cut by levees until they were quite sure that all the lands below were well protected against inundation. As the first lands to be reclaimed were in Louisiana, the next basin above it is the Tensas. They would have done one of two things. They would have either run the levee down one half the length of the Tensas, letting the other half be flooded, or they would have taken half the basin in the length of the river and surrounded it with levees, and let the river go around the other half. But they would not have allowed a levee to be put up until the lower ones had been strengthened. Having done that and allowed eight or ten years for the river to adjust itself to the new conditions, they would have gone to the next basin, the Yazoo, and taken half of it and treated it in the same way, previously protecting all the levees below. Then in thirty or forty years they would have gone to the next, the St. Francis, and taken half and treated it the same way, taking care that everything from there downward was well above the level of any possible flood.

As this operation went on and the waters were cut off from overflowing the basins and kept within the channel, the river would gradually have widened, and may be deepened itself, to meet the new conditions. It would have needed time for that, but you people in this country give nothing time, and the Mississippi River has had no time to do anything in all the operations that have been performed on it. Every time a breach or crevasse occurs in a levee the river down stream for 50 or 60 miles is totally disorganized and all the good done in previous years is thrown away, and the work of making the channel suit its new conditions has to be done again. If it had been done in the way the ancients did, the Mississippi, with its 19,000,000 acres of valley, would have had 9,000,000 acres thoroughly reclaimed, and 10,000,000 acres still covered with water in flood time—and being greatly improved with the mud deposited on them.

Acting in a way different from this, and letting everyone do that which was good in his own eyes, no more than about 4,000,000 acres have been reclaimed, instead of 9,000,000, and much of it indifferently, while the primeval forest covers by far the larger part of the land.

Some may say that this is purely an academic discussion. This is what the ancients would have done. Now, the question before us is with the river as it is; supposing the ancient engineers came into this valley as it is to-day, what would they have done with it? I will first describe what the Mississippi Valley is to-day. If you go down from Cairo, the first basin on the right bank is the St. Francis, with 4,000,000 acres, and it has a levee along almost its entire length. The Yazoo basin of 4,000,000 acres on the left has a levee along almost its entire length. On the right bank the Tensas with 3,000,000 acres has the same; and from the Red River on, both banks have levees past New Orleans to the sea. The small basins are unprotected.

I will lay down a few propositions. Before a basin like the St. Francis is allowed to have a levee, from the end of that levee downward, calculations should be made and the height of the flood which is going to be artificially produced by that levee, calculated. Then profiles of levees 5 feet above flood should be put up, 10 feet wide, every 10 miles all the way down the river, so that every man could see for himself the terrible condition that is coming.

If, for example, the Mississippi when in its banks, discharges 1,000,000 cubic feet a second with a velocity of 6 feet it has worked out for itself, owing to the kind of soil which it has in its valley—and a very poor and bad soil it is to resist the current—it has cut out for itself a channel 5,000 feet wide and 33 feet deep. If you put the whole discharge of 2,000,000 feet a second, that passes Cairo, into the stream it would begin by having a depth of 48 feet or it would rise 15 feet at once, and with its width still 5,000 feet, a velocity of 8 feet a second, which is a great increase. It would undoubtedly begin to widen itself. This river has a width which is 150 times its natural depth, so that when you increase its depth by 15 feet it would want to increase its width by over 2,000 feet. But as it increases its width by every 10 or 11 feet, the section increases and its depth falls. With water which is wonderful in its adjustment, the stream would adjust itself, and in time, if left alone to work out its own salvation, it would become a river about 6,500 feet wide and say 40 feet deep. And so gradually working in this way, you would have got your river only 7 feet above its banks in highest flood. But working suddenly and raising suddenly is not engineering.

More important even than the levees as the river sweeps around its bends in its valley are the protective works at its sides. This protection is very well done in this country. Not enough is done to keep pace with the requirements of the river, but what is done is well done. The river, instead of tearing down its banks in poor soil, is fixed by matting and stone, as though it was flowing between hills. With these protective works I consider that, if the river in its natural soil can run 6 feet a second without difficulty, it could take 7 feet quite easily if well protected. Now, in this country there is no nervousness in raising the water 15 feet in height and increasing the velocity from 6 feet to 8 feet, but the extra velocity that would come from these great bends being cut across to make the channel shorter has occasioned extraordinary nervousness. Yet of the two, as I see it, this is the less dangerous. If you increase the velocity from 6 to 8 feet, that velocity goes clear down the whole river; but if you cut off a bend and increase the velocity at any point, you immediately decrease the depth, and this has a wonderful way of adjusting itself. This I have seen for myself. But if you let a cut-off take place in a high flood when the river is full and velocity very great, you court an enormous amount of damage. Such things the ancients would have done just after the flood. They would have cut it so that the river would have had eight or nine months to flow under its new conditions, and when the next flood came it would not have been very serious, as the river had adjusted itself to its channel. For in all such rivers, if you can get the low water supply to flow in any channel, and it is happy in that channel, the flood will follow it without any difficulty. I assume that the salient bends are well protected with mattresses and stone in your best style. Well burnt, huge bricks of the Babylonian type might be cheaper and better than stone. Great monoliths might be fused in this way.

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Where the levee is far away from the mattress protections it might pay to protect only 1,000 feet per mile and let the river bite into its banks between these fixed points. There would be a limit to the biting action, and a million dollars might go as far as three million would go if you protected every inch. It is worth trying where the levees are far back.

It is often said that the river Theiss, in Hungary, was a winding river, and they cut off the bends with the result that the water swept down the valley and destroyed the towns and lands lower down. But that was very foolishly done. If instead of beginning at the source and cutting 10 or 12 bends off at once, they had begun from the bottom, or mouth of the river, and worked upward, cutting off one a year, they would have had none of those difficulties, and the citation of this river as a type of that kind of work is not an accurate thing. It was a very badly managed job.

When once a river has accustomed itself to a new channel we know from the river Nile, whose records go back 5,000 years, that streams like these raise themselves gradually on their beds very slowly. The Nile Valley rises about 5 inches in 100 years. (The Euphrates has risen about 1½ feet.) So steady is this rise that to-day if you dig down 21 feet in the Nile Valley and find the foundations of a building you can calculate the number of years at 5 inches for every 100 years, and you can say B. C. 4,000 or 5,000, or whatever it may be, this building was built here. And when you dig it up and find the remains you are nearly always right, as the rise has been steady through all the centuries. And although no records of this kind go back in Babylonia, yet the same thing is true, because the foundations of the different buildings in different ages and the different facts recorded all bear witness to this steadiness of rise of the country.

Now I repeat that of all the things you do on the river, the first and most important is to protect the cutting of the banks at the salient bends; because when you increase the velocity and change the river from what it was, the thing to do is to fix the points within which it must flow. While it wanders inside those limits, it does not matter what it does.

I have considered this problem only to the Atchafalaya Escape at the Red River, because below this there need be no difference. This is a very efficient escape which goes into the Gulf of Mexico, and is capable of taking away all the excess waters. I have seen it stated that a river is spoiled by having an escape like that, but I think that is a misstatement. If a river is carrying 1,500,000 cubic feet a second in flood and a breech occurs on one bank, and 500,000 cubic feet goes away, and that stream, discharging 1,500,000 cubic feet, suddenly finds itself carrying only 1,000,000, the silt is immediately deposited. But if you have a river capable of carrying 1,500,000 cubic feet and it suddenly has 2,000,000 cubic feet put into it, I think it is a wise thing to let that extra 500,000 cubic feet go down the escape and never enter the channel capable of carrying 1,500,000 cubic feet. I am rather rusty in my Latin, and I wish you to correct me if I am wrong, but I think the old Latin phrase is "*Natura non facit saltum*," that is, "Nature makes no leaps." It is not the deliberate removal of water, but the sudden removal by breaches or crevasses which is so harmful.

There is no reservoir that you can find for a river so good as one of these open basins on its banks. The river carries its 1,000,000 cubic feet per second and it is within its banks. As it rises above 1,000,000 it overflows not in one place, but in a hundred or a thousand or a million, along its entire length of bank. That kind of overflow does not disorganize the stream, for it leaves the stream in perfect order and relieves it of all excess of water, so that if you make a levee along one bank of the river and let the other overflow, you get a moderately increased scour under control, and not out of control, as it is if levees are built on both sides. The ancients did this always. They built a levee on one bank, and when the river was capable of passing the excess of water with one levee, they went to work on the other. In this country you have brought both levees up together. If the central government were to say to a State, if you put up your levee where we are not prepared for it we shall give you no help, the State would wait until the levees below were ready, because no one in the valley would move a hand's breadth if they were *sure* that the central authority would give them nothing.

We often hear it stated that things are better to-day than they were in 1882, when there was one of the greatest floods the Mississippi has known, because there were 442 breaches then and only nine in 1912. But when the water was only of a moderate height above the country, hundreds of breaches would not do as much harm as one breach when it is 12 or 15 feet above the level of the country. To compare these many breaches with one large breach is very well explained by a fable of Æsop which nicely expresses this situation. The lioness with her one cub went out for a walk and met the fox with her ten cubs. The fox called attention to the great discrepancy in numbers between her cubs and the lioness'. The lioness replied: "My dear woman, *this* is a lion."

To-day a new difficulty has begun to appear owing to raising the water on the levees up to 10, 12, 14, or 16 feet. These are "boils." Where the water is 5 or 6 feet high on a levee there is no difficulty. But where the water rises, it forces it way through decayed trees buried in the soil under the levees, or through holes bored by crabs, and bursts out on the other side like a geyser. Many breaches in the last overflow they say are attributable to this sudden undermining of the levee which no human being could foresee.

So serious has this become to-day on the Mississippi that Major Dabney, one of the most experienced of the Government engineers in the valley, thinks it may be necessary to build two levees, one behind the other, which will add many millions of dollars to the expense of this work.

I have often heard it said that it seems a pity to allow any land not to be protected by a levee and to leave it open to the floods. But when you consider that out of the 12,500,000 acres in the upper valley, there are only 4,000,000 cultivated to-day and 8,000,000 are still primeval forest, to go ahead and throw up levees to drown out people down below in order to protect a large area of primeval forest is not doing any good to the country, but rather harm. While if the water was allowed to flow over this land, not as it likes, but within dikes carefully done as it is in Egypt, this land in 20 or 30 years would be so much improved that those people whose land was outside the levees would possibly find themselves better off than those who had been inside the levees. In two years out of three they could get first-class crops on unprotected land; and even in bad years a half crop if they wished.

With these propositions, I shall now go to the question of what the ancients would have done if they found themselves in the valley to-day. The first thing I think they would have done, judging from what I have seen in Mesopotamia, they would have protected the salient bends. They would have taken care that there was no more eating away of levees. There is no use putting up a very expensive levee here and there and letting the river eat it away. Little progress can be made in this way. You are always spending your money in repairing. And this point is very well insisted on by the Government engineers and they carry it out to the limit of the growth of the stuff of which the mattresses are made. But more than that might be done now with reinforced concrete at your hand. The stuff of which they make mattresses can only grow at a certain rate, but this reinforced concrete can be made anywhere, and you could keep ahead of the damage that is going on in the valley. The conditions on the lower Mississippi to-day are very serious, and delay may produce a flood which may be not unlike Noah's flood, some day.

All cutoffs would have been allowed by the ancient engineers, according to all their works which I have seen. They would never have spent great sums of money to prevent the river from cutting away inside the channel, because it only takes away money and labor from attending to the main object of keeping the two main levees protected. All money spent inside to keep these bends from cutting across is money thrown away. There is nervousness about this cutting, which is not warranted by anything I have seen. I remember on the Karun River in Persia years ago, the river took an 8-mile curve and came back again to the same point, and you could see it 4 feet higher on one side than on the other. They said whenever that is cut through navigation will be upset for a long time. It cut one day, and within a week the river was flowing in its new channel, and it was difficult to see how it had run around the 8 miles because it seemed to be so happy in this new channel, just as if it had been there from eternity.

The next thing they would do, I think, would be to calculate what the height of a 2,000,000 cubic feet per second flood with 10 per cent added, or 2,200,000 cubic feet per second, would be in the valley, and put up profiles from Cairo down to New Orleans and let everybody see what it meant to have water like that clear down the valley. You have had floods, but you do not yet know what it means to have a very high flood without a breach. This country, it seems to me, has so many problems and big things before it that questions on the lower Mississippi, however serious they may be, are allowed to drift, and yet they reflect on your country, and make it appear just like China, or one of those derelict countries like Mesopotamia.

The next point. Even now though the levees are too long and everybody knows it, the engineers and the government do not prevent the Yazoo and other basins from extending their levees further south, or the St. Francis basin from extending its levee and making the difficulties greater than they are at present for those people still farther down the river. I have been a government official for twenty-four years under strong central governments, and they say to any one "Lengthen that levee even 1 inch and we will not protect a single inch of it." No more was necessary. No one would dare for a minute to do anything against the will of the government which had all the money in its hands and to whom everybody appeals for help.

Allowing 6 feet above the bank as not a dangerous height, I calculate that we need reservoirs on the Mississippi which represent 34,000,000 acre feet, that is 34,000,000 acres 1 foot in depth, or 1,000,000 acres 34 feet in depth, or something between them. To meet this we have the left-hand small basins and the Yazoo and others open at their ends where we have 6,000,000 acre feet, so we need 28,000,000 acre feet, to be provided by reservoirs. Reservoirs up in the mountains and in the clouds I don't think would affect the Mississippi. They would be so late or so mismanaged that their influence would never reach the place in the nick of time. I am reminded of one of the sayings of Moses to the children of Israel when I hear people saying that if you will only put forests on the hills and put reservoirs up at the heads of the Mississippi River, you will settle the question. This question came up in Moses' time, and he said "Seek not for salvation at the tops of the hills, look not for it at the ends of the valleys, for thy salvation is nigh thee, at thy very doors." We have got the St. Francis basin, far cheaper than any reservoir and one of the cheapest in the world, of which three quarters would suffice for our needs. Let them protect the upper quarter with levees and let three quarters of the basin be allowed to be put under water and it would protect the Mississippi River for 20 or 30 years, until the river had widened its channel. In the meantime, with transverse dikes from the river to the hills, well adjusted and employed like the ancient Egyptians did theirs, you could let the muddy waters of the Mississippi flow over this basin so that the lands would be greatly improved, and when the time came for the owners to enter into possession they would be much richer than they are to-day. If you go across this basin down a range of 40 miles, you see only a few wooden shanties and a little clearing and cultivation, and everything else primeval forest. To protect this primeval forest and put the whole river for hundreds of miles into extraordinary difficulty is foolish. If the people don't like it, the central government could buy this land. If you make reservoirs in the hills, you will have to buy the land which is to be covered and you will put that out of cultivation forever; while using this basin, far from putting it out of cultivation forever, you would after 20 or 30 years make it many times as rich as it is to-day, and if the central government purchased it, they could afterward sell it at a handsome profit.

Nature has succeeded very well in all her efforts because she has a law. It has been well expressed in the lines "So careless of the single life, so careful of the type." In the Mississippi Valley you see that everywhere the action of this country has been "So careful of the single life, so careless of the type," and unless a return is made to Nature's wise law no permanent improvement can be assured.

I have already spoken of forests, so I need to say little here. There are a few people who have planted oaks, chestnuts, and other fruit-bearing trees on a few acres of land that belong to them and have made money. This is far from saying that every single man who has a square mile of hillside in the country will go at once and plant trees. Ninety-nine out of 100 people are lazy, and they are not going to plant the hillsides with trees. So Uncle Sam, the kindest-hearted man that ever was known, is called on to plant the forests. Those forests, scores or hundreds of years hence, will help the stream in low supply and ordinary floods, but they will have no effect upon it in the heaviest floods, and these are the floods we are concerned with.

If you build reservoirs up in the hills or build a dam across the valley, you must first have expensive openings in it so that the waters may traverse it in order that it may be empty when it is needed. If it is full or water when the rain comes it will be useless. So that these reservoirs that are provided for flood protection cannot be used for supplying power or helping navigation.

And moreover, what is the use of protecting 10,000,000 acres in the Mississippi Valley with levees, when only some 4,000,000 are cultivated and the rest is primeval forest, and there is neither population nor money to reclaim it.

The people of the Mississippi Valley for many and many a year have been rightly nervous, and advantage is being taken of this nervousness, for everyone with a panacea to go shouting that something must be done at once. Now there is a very well-known saying of Lord Palmerston's: "Where you hear a number of people saying that something must be done, something must be done at once, you may be quite sure something very foolish will be done."

I have spoken of the Mississippi. I now come to Pittsburgh. We have here the same problem as on the Mississippi, but in a smaller way. The only difference is that on the Mississippi the man on the right bank worries because the man on the left bank puts up a levee. Here you have the satisfaction of knowing that you have created your own difficulties. You have two rivers, the Allegheny and Monongahela, with only 20,000 square miles drainage basin, which really is not a big thing. It is the first small thing I have seen in America. Your rivers are quite ordinary rivers, but they have for short intervals of time most extraordinary floods. The maximum floods they carry are just about what the Tigris and Euphrates carry when they meet. Those rivers have it for months and you have it only for a few hours. But a few hours of water flowing through your house is almost as big a worry as having it for a week.

These two rivers as they come down do not have big reservoirs as the Mississippi has lower down, but they had very fine reservoirs at one time. First of all there were the overflows in the valleys themselves. Then going back in every direction were the side valleys, wide in places and narrow in others. With a river that comes down in high flood for months they would have been of no use, but with a river that comes down only for a few hours or days, the valleys gave ample elbow room, and by the time the flood got down to the Ohio River, all its force had been spent in filling up these side openings and before it had time to fill them all full the storm had ceased and the flood had passed.

Now what have you done in these years? You have deprived the river of all elbow room. I saw a bridge where the river was 1,300 feet wide, and to-day it is only 650 feet. Nearly half the river has been filled up with factories, with railroads, and with every kind of industrial institution. Then you have erected numerous bridges not with piers one in front of the other, but all irritating the river and holding up the water in every way they can. Now when the river comes, instead of having elbow room as is had in the old days, it finds itself contracted within two solid walls. And if you calculate the height it has come up above the old floods, you will find it has made up in height for the area you yourselves have taken away from it on both sides.

I have heard it said that railroads and factories join in these petitions to Uncle Sam to help them out of their difficulties with reservoirs. The only thing I have been able to compare it to was a case that happened in Europe some years ago. A boy of nineteen murdered his father and mother, and when he was up for sentence the judge asked him if he could mention any extenuating circumstances, he said "I appeal as a poor orphan." These people are very different from those poor people who live in houses that used to be above the flood and now find the water flowing through their drawing-rooms when they least expect it.

As far as I can see, you have no more difficult problem here than the city of Rome had where in the course of years the Tiber had risen 10 feet above the Aventine quarter. They spent many millions of money, but they bought all the houses on one side of the river and whitened the channel about a third wider than it was, built two walls and raised the banks, and now the whole town is protected. It cost a great deal of money, but they had no one to appeal to but themselves to do it, and they did it. In Pittsburgh, too, a wall has been proposed. I speak under correction, but when I see the shingle and stuff on which you are founded I think a wall would not prevent water from coming up from underneath; but it would be easy to raise the streets on both sides of the river and then when the flood came it should not get across it, and whatever water seeped through into cellars might be pumped out over the banks. Whether reservoirs are made or whether they are not made, I think this street raising ought to be made on both sides straight away like Rome. If you do make reservoirs and you have a basin of 20,000 square miles, and your reservoirs cut off the water of 10,000 square miles, you still have 10,000 square miles this side of the reservoirs, and if you have a heavy downfall of rain on that, it might bring down quite enough to worry you, especially if you had warm rain on top of snow. I think reservoirs ought to be made if they can be made, but whether they are or not the streets should be raised by earth, and if every load of earth you used were taken from the river you would improve the river to that extent.

The factories and railroads, built low down near the river, must be raised on their own base. I do not know the cost of raising them or whether it is worth while to do it, but considering the millions of dollars they lose owing to the floods, it should be worth doing. No reservoirs in the world could lower the water sufficiently to keep the floods out of them.

For navigation as I see it, there is no better plan than you have, with your weirs and locks, but you have an acid water which eats iron in an extraordinary way and any kind of permanent weir which would not necessitate these iron structures that raise it temporarily would be a great gain. This point was brought to my attention by Capt. Fiske. He said, "Why couldn't they make bars across the river in places so as to have sufficient length to have no movable apparatus in it and make them of such height that it would suit low water and floods would pass safely over?" This is certainly the correct way for this kind of work, and I had the advice of some of the best men in India when I proposed it for the Tigris. There are many places on your rivers where you could build permanent weirs of a height to suit low-water navigation and the high-water would flow over very freely. On the Nile we built permanent structures 9 feet above bed level of the stream, which hold up 9 feet of water in the summer time, and when the floods come you would not know there was anything in the river at all, because when the river rises 30 feet a 9-foot obstruction does not count for anything.

Still in an important city like Pittsburgh in addition to whatever you do, something in the way of reservoirs ought to be done if it can be done. In a recent book which you have written on this reservoir question I see that the quantity of water you consider necessary to impound in these reservoirs seems to be in excess of what you need. In all the calculations it has been assumed that when the river rises, its discharge increases up to its maximum gage. As a matter of fact, it does just the opposite. When it is rising fast, it has a great velocity and a great discharge, but when it comes to within 7 or 8 feet of the top, the velocity has begun to decrease and with it the discharge. On the Tigris, which jumps up and down very much like this, when the river gage is 15 feet rising, the discharge is 180,000 cubic feet a second. When it has risen to 20 feet and reached its maximum for that rise, its discharge is 120,000, and when it has come down on the other side to 15 feet the discharge is 90,000 cubic feet per second. As in all these estimates, you have allowed for an increasing discharge, and not reduced by half for the falling gage, a much smaller quantity of water than you have assumed would, I think, suffice to shelter you from these hours of high flood which produce all the worry.

The difficulty here, I think, is that the same operation which made your soil very rich in coal has made it very bad for reservoirs. This horizontal sandstone you have here and shale in alternating strata is considered the worst foundation for reservoirs of anything in the world. More accidents to big reservoirs have happened on it than any other. If the strata are inclined at a steep angle, and you build your dam on it, it rests on the hard particles, and the weak strata are more or less ignored. But if you have horizontal strata and you hold up water with a 150-foot head, the water works its way through the shale and gradually undermines it; because horizontally it can do it very easily, and when it reaches a certain point the upper strata settle and the dam collapses.

In your book you show that you spent money on many things, but not one penny to find out what your foundations are, and all the rest of it is worth nothing until you are sure of your foundation. You ought to spend some $10,000 for drills and take two of the nearest sites and expose the foundation and see if you can build a dam there. If you find really good foundation, your difficulties will be at an end. There are many sites in Algeria where the French government would give anything to be able to build a reservoir on soil like this. In despair they did build one, but in a few years it was swept away. And your condition is such that if you had a high flood and a reservoir with 150 feet head on the hills above you and it happened to breach and came on the top of the flood, all the disasters you know of to-day would be but child's play. And if you had two in the same valley and the upper one burst and came down on the lower one, and the two came together, you might open the early chapters of Genesis and begin reading about Noah's flood to comfort you. So of all the things that are necessary the first is to be sure. Reservoirs with good foundations up in the clouds are no use. Even if you could open and shut them it would be too slow coming on its way. They must be low down. I never saw such bad-looking stuff for reservoirs, and I found that no one had bored down one foot to see. For when you have bad rock it is often necessary to go down 50 or 100 feet, and when the water flows through the dam you have got to make an apron down stream 100 yards wide in order to protect the rock from the action of the water. You have two expenses, one a very expensive dam and the other a very expensive floor down stream to prevent it from being undermined. As far as reservoirs are concerned, if you had granite or steeply inclined crystallized limestone of any of the good rocks in which reservoirs are built, I would back your reservoir project against all the others. If ever the central government pays for the reservoirs, it would be your certain duty in this town if a reservoir were built near here, to see that the foundation were good. Because rivers with rock suitable for foundation have been controlled; it does not necessarily follow that you can do the same if you have no suitable rock. You read in the Acts of the Apostles that the seven sons of one Sceva, a Jew, saw St. Paul casting out a devil, so they thought they could, but the man possessed of the devil leaped upon them and left them wounded and half dead. You see their faith was not well founded.

If the reservoirs can be made, or if they cannot, the duty of raising the streets on both sides sufficiently high to protect the lower parts of the town is incumbent on you.

A Remedy for Beri-Beri has been discovered, according to the last annual administrative report of the Federated Malay States. Pending a thorough investigation by the medical research institute of the colony, the details of the remedy are not announced.

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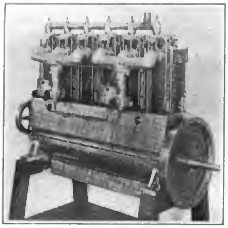
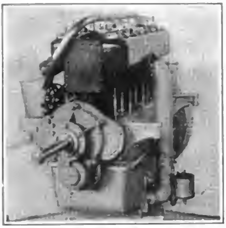
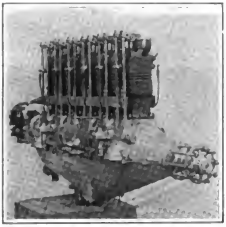


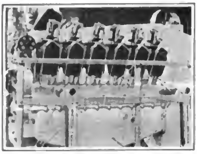
Intake side of latest Wright "6-60" motor, showing carbureters, removable crank-case lid, and general accessibility.



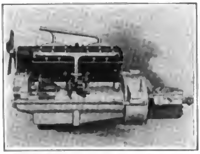
100 h. p. Sturtevant, showing propeller gear housing, reducing from crank shaft speed of 2,000 r.p.m. to 900 r.p.m., a more efficient propeller speed.



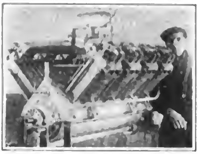
One hundred horse-power Benz. There are two spark plugs in each cylinder. Note general freedom from piping and plumbing paraphernalia.



The 12-cylinder, 100 horse-power Renault aero motor. Air cooled by fan blower.

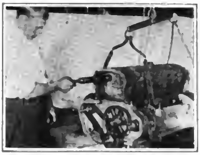


Speedwell rotary-valve automobile motor, built under the Mead patent.

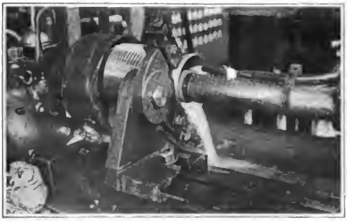


The new 200 horse-power Curtiss engine, which has two intakes and two exhaust valves in each cylinder.

90 horse-power Austro-Daimler installation in Thomas flying boat. Starting crank enables pilot to start engine without leaving cockpit.



Mead engine, showing silent helical gears and chain driving magneto and electric starter. One rotary valve half withdrawn.



French construction methods. A cylinder at the Gnôme works being bored out from the solid billet.

The Gnôme "artillery." Motors on the testing stands at the Gnôme works in France.

THE INTERNAL COMBUSTION MOTOR IN THE FIELD OF AVIATION.—[See page 24.]

The Channel Tunnel and Its Early History—I*

Plans for Direct Railway Connection Between England and France

By John Clarke Hawkshaw, M.A.

Now that the Channel tunnel question is again under consideration, I feel that it may be of interest to others if I set down some of my recollections of the work which was done, some fifty years ago, to find out whether the natural conditions to be met with in making a tunnel were such as to warrant the work being begun.

No one who has any correct knowledge of the facts can deny that the most useful and practical work to that end was first begun and carried through to a satisfactory end by my father, the late Sir John Hawkshaw.

Before he undertook the work suggestions had been made and lines for tunnels had been laid down, but these were all based on conjecture, for no one could say through what material such tunnels would pass beneath the sea, and without that knowledge the opinion of an engineer as to the prospects of success in carrying through such a work would be of little value, and any estimate of the cost would be worthless.

I am the only one now remaining of those who were intimately associated with my father in the systematic investigation which he began in the year 1865, and which, when it was concluded, led to the formation of the Channel Tunnel Company, of which Lord Richard Grosvenor was the chairman. I attended meetings in this country and in France, was present at all the trials of machinery for excavating and transporting the chalk, and took part in the calculations, more especially in those for the difficult question of ventilation, which my father left to me to work out. I had had much practical experience in tunnel work. For five years I spent some days every fortnight in going through the Severn tunnel works—a submarine tunnel four and a quarter miles long—and I discussed every detail of this work with my old friend, the late Mr. Thomas Andrew Walker, the contractor. I was also familiar with the work on the Brighton intercepting sewer—a work of my father's—which tested beyond all others our power to deal with water in the chalk.

I have given time to the study of geology since I was a boy, and know the chalk cliffs well in France, and from Dover to Folkestone, where I have worked with a pick and shovel collecting fossils with Griffiths, formerly a well-known dealer in them at Folkestone.

I hope you will pardon these personal remarks, but it is well my hearers should know that I do not come before them without some experience of the subject of which I treat.

It was M. Thomé de Gamond who first, by long and patient study of the geology of the Straits, tried to show that a submarine tunnel could be made between England and France. This careful study was the first step taken in the right direction. Unfortunately he gave no attention, as my father did, to the question of what was the most favorable stratum for tunneling operations—the chalk. He seems to have assumed that the chalk was denuded in the Channel, and so he occupied himself solely with a careful survey of the oolitic strata west of Dover. These beds could be well studied in France in the neighborhood of the Straits, and he obtained some fragments of rock from the summit of the Varne shoal, which he correlated with the beds near the French coast. Unfortunately the oolitic beds do not appear on the English coast, and he had to go as far as Oxfordshire to study them in England. He assumed their position under the Channel from his observations made in Oxfordshire and in France, checked to some extent by his fragments from the Varne. It is obvious that any section under the Channel formed on such data must be purely conjectural, and no one knew this better, or was more ready to acknowledge it, than M. Thomé de Gamond, who relied on future borings being taken. He laid down his line of tunnel from Eastwear Bay, east of Folkestone, to Cape Grisnez, hoping to keep in certain beds in the oolite under the sea. He proposed to make some thirteen islands in the Channel, so as to begin the tunnel at many points by sinking shafts in them.

After my father's inquiry was completed, M. Thomé de Gamond abandoned his own plan and become a member of the committee which adopted my father's.

Sir Francis Fox lately stated at a public meeting that Stephenson, Locke, and Brunel approved of M. Thomé de Gamond's line. If they did so without very wide qualification, they, for once, forgot that caution which is inseparable from all engineering eminence, and gave an opinion with an insufficient knowledge of facts. Neither M. Thomé de Gamond nor anyone else could at that time tell what material would have to be tunneled through in the line he chose. That being the case, any opinion as to the practicability of such a tunnel could be of little worth, and no estimate of cost could have any approach to accuracy. Other engineers followed M. Thomé de Gamond: Mr. Brunlees and Mr. Low were advocates for a Channel tunnel, but they had no more detailed knowledge of the facts than M. Thomé de Gamond, if as much, though they had more practical knowledge of work underground, Mr. Low being a mining engineer.

For some years before 1865 Sir John Hawkshaw had been considering the practicability of a tunnel under the Channel, but with his sound common sense, and with a modesty for which all who knew him would give him credit, he did not in any way try to influence public opinion, knowing that the facts to hand were quite insufficient to warrant any proper opinion as to the absence of risk of failure.

In 1865 he began, at his own expense, a private inquiry untrammeled by promoters or associates, to acquire as accurate knowledge as was possible of the nature of the material under the sea. A knowledge of this was the key to the problem. The facts which he collected, after several years' work, as to the nature of the bed of the Channel and what lay beneath it, not only enabled him to form an opinion himself, but they first gave the Channel tunnel question a solid basis. From that time on, the possibilities of making a Channel tunnel and its probable cost could be profitably discussed by practical engineers.

I will now proceed to describe the nature of the inquiry which Sir John Hawkshaw thought necessary before venturing to give an opinion.

First, it was necessary to know in detail the kind of material to be met with on the English and French shores of the Channel.

The geology of the coasts was fairly well known, but it was necessary to study the strata also from an engineering point of view—to make sure that identical beds were found on the two sides of the Channel, to note what facilities the strata offered for tunneling work, and the risk to which they would give rise if they allowed of a too free passage of water.

Early in 1865 Sir John obtained the services of Mr. Hurtsinck Day, who, besides being a competent geologist, had also a knowledge of surveying.

Mr. Day's attention was directed principally to the cretaceous beds which Sir John's large experience in tunnel work led him to choose as the most promising material through which to tunnel.

Mr. Day spent several months, in 1865, in examining and surveying the cretaceous and adjacent beds on the coast in England and France, and prepared a geological map showing their position on both sides of the Channel, and he also made a map based on conjecture as to the position of the beds under the sea. (See plan.)

A glance at a map of the Channel will show that the narrowest part lies between the Foreland (near Dover) and Sangatte. A tunnel between those places would be the shortest that could be made, but could it be kept wholly in the chalk?

The cliffs of the Foreland were chalk, but to what depth did it extend? Chalk was not visible at Sangatte. At what depth was it to be found, and what was its thickness? To answer these questions Sir John Hawkshaw determined to bore through the chalk on the English and French coasts. The well-known contractors, Mr. Thomas Brassey and Mr. George Wythes, and Mr. Easton, who had done much work in the chalk in search of water for town supplies, were interested in my father's inquiry, and offered to share the cost of these deep borings, which in those days were more costly to carry out than they would be now. The points selected for the borings were St. Margaret's Bay in England, distant four miles east of Dover and about eight miles east of the outcrop of the lowest beds of chalk on the coast, and Ferme Mouron in France, two and a half miles west of Calais and four miles east of the outcrop of the same beds on the French coast.

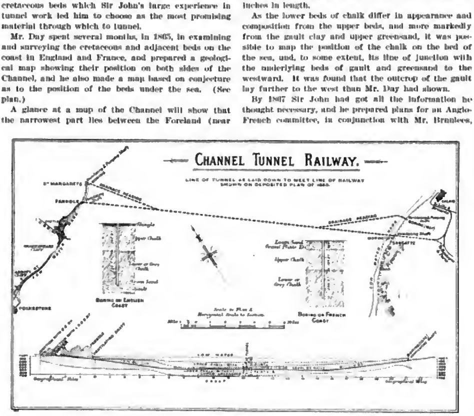
These borings showed that the thickness of the lower chalk does not diminish to any extent as we follow it to the eastward along the coast.

That the chalk extended under the Channel no one now doubted.

The all-important and last remaining point to be settled was, would the chalk be found in the Channel on the surface, or at some depth below it covered by superficial deposits? To ascertain this and check Mr. Day's conjectural plan of the geology of the sea-bed, Sir John employed Mr. H. M. Brunel, one of his pupils, who was still at work in his office. In the years 1865 and 1866 Mr. Brunel carried out a marine survey from a small steamer hired for the purpose, taking advantage of any favorable weather by day or by night. The position of each sounding made at night was fixed by taking angles from the stars. The greatest credit is due to Mr. Brunel for the careful way in which he did this survey, and the accuracy with which he worked out the observations fixing his positions. He soon found out that bare chalk was exposed on the bed of the Channel. An ingenious form of sounding-lead was devised. Round a piece of wrought-iron pipe a heavy sounding-lead was cast. The pipe, which had a sharp chisel edge on the lower end projecting some way out below the bottom of the sounding-lead, was driven by the descending weight into the sea-bed, and brought up a small cylinder of chalk or gault clay, often some inches in length.

As the lower beds of chalk differ in appearance and composition from the upper beds, and more markedly from the gault clay and upper greensand, it was possible to map the position of the chalk on the bed of the sea, and, to some extent, its line of junction with the underlying beds of gault and greensand to the westward. It was found that the outcrop of the gault lay further to the west than Mr. Day had shown.

By 1867 Sir John had got all the information he thought necessary, and he prepared plans for an Anglo-French committee, in conjunction with Mr. Brunlees,



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* Paper read before the Royal Society of Arts, and published in its *Journal*.

Mr. Low, and M. Thomé de Gamond, showing a tunnel through the chalk from St. Margaret's Bay in England, to Ferme Mouron in France.

In 1868 the Anglo-French committee applied for a concession from the French government. This led to a long correspondence between the two governments.

After four year's existence as a committee, the English Channel Tunnel Company was incorporated in 1872. This originated the French company, and my father supplied the plans on which their concession was obtained in 1875. By it they were bound to spend $400,000 in preparatory works of all sorts, such as investigations, pits, galleries, borings, etc. The conduct of these operations was intrusted to Mr. Lavalley, so well known in connection with the Suez Canal works. The geological work was assigned to MM. Potier and Lapparent, mining engineers and able geologists, and they were assisted by M. Larousse, hydrographer to the French navy. They began by repeating, and extending on a more elaborate scale, the marine survey made ten years before by Sir John Hawkshaw. Using a sounding apparatus of the kind already mentioned, they succeeded in bringing up a great number of specimens of the rocks forming the sea-bed. These soundings confirmed, in all material points, Brunel's survey made ten years before. Furthermore, owing to the great number of soundings that were taken, and to the number of specimens from the bottom that could be identified, it became possible to plot with some accuracy the junction of the lower chalk and gault from shore to shore, except for a short distance where these beds pass beneath the sands of the Varne. A second boring was made at Sangatte, and the results of this work, done in 1875-76, were published in 1875-77 in the form of reports, with maps and sections.

The researches by the French company brought no very novel facts to light, such as to disturb the main conclusions which had been already arrived at in this country as the result of my father's work, but they made our knowledge more definite in several particulars. Mr. Topley, of the Geological Survey of England, reported to the Channel Tunnel Company in 1878, and advised that the outcrops of the gault, as shown by the French engineers, might be taken, for all practical purposes, as accurate.

In the year 1882 the Channel Tunnel Company sought to obtain parliamentary powers, and deposited plans showing the line of railway on the English side to join a tunnel from Fan Hole to Sangatte 20.8 miles long under the sea. (See plan.) This tunnel ended in Dover, just behind the castle, with the mouth of the tunnel facing the fort, the guns of which could be pointed into it. It appeared to me that this was a very safe place for the tunnel to enter England, but the military authorities thought otherwise. Before the plan was deposited it was submitted to them, and the War Office appointed some of its officers to visit Dover and approve or not the proposed exit of the tunnel. For some reason my father was unable to be present, and I had to act as guide to the deputation. I only remember two of them, Sir Archibald Alison and Sir Andrew Clarke. I was much disappointed when the outlet was condemned, and I well remember Sir Andrew Clarke saying it would be contrary to all precedent to have an opening from without inside a fortress. I had to set to work at once to find another outlet, which I fortunately did in the valley of the Dour, not far above Dover, so that little was added to the length of the tunnel. A new survey was made, and a parliamentary plan was deposited with the new outlet.

In the same year (1882) the South-Eastern Railway Company sought for parliamentary powers. The chairman of the South-Eastern Railway Company had determined that the Channel tunnel should be a South-Eastern affair. To this my father, who was consulting engineer to that company, had strongly objected. He thought a Channel tunnel ought not to be a one-company affair, and so strongly demurred to the course taken by the railway company that he withdrew from the post he had held for so many years as their consulting engineer.

The plan put forward by the Channel Tunnel Company was a complete scheme, while that put forward by the South-Eastern Railway Company was anything but complete. If Sir Edward Watkin, the chairman, had a definite proposal he did not disclose it. The railway company were tunneling in the grey chalk at Shakespeare Cliff, but in what direction the tunnel would go or how it was proposed to drain or ventilate it, no one knew.

On the other hand, every detail for the completion of the Channel Tunnel Company's work had been considered. Their tunnel was to go in a straight line between Fan Hole and Sangatte, with an exit near Dover, where a junction could be made with the railways of the South-Eastern and Chatham and Dover companies. It was to be provided with drainage headings to drain the tunnel by gravitation from the highest point in the center of the Channel to pumping shafts on the two shores, the positions of which were fixed.

I have just read an article in the *Revue de Deux Mondes* by M. Sartiaux, which seems to indicate that it is now proposed again to put forward the line prepared by Sir E. Watkin from Shakespeare Cliff, and to endeavor to keep the tunnel in the lowest beds of the chalk, not in a straight line or with regular gradients, but following the grey chalk in all its sinuosities. A drainage heading is to be made on a line fixed provisionally, but which may be varied by the knowledge of the strata gained from weekly borings, which will also determine the direction of the main tunnels, and consequently their length and cost. The drainage heading will meet the main tunnels at a point near the middle of the Straits, from which the main tunnels will rise, and the drainage heading will fall toward the shore. They will also diverge from this point so as to keep in the same bed of chalk, which is deeper down as we go up the Channel. Cross adits will be driven from the drainage heading to the main tunnels as their direction is determined by the borings.

Now the making of numerous borings is what a hydraulic engineer would do if he wanted to strike fissures in the chalk to get a water supply. The more borings made the more water he would hope to get, and would most likely not be disappointed.

The grey chalk is not free from water, as we know it on land, and to a certain extent under the sea. I saw many small runs of water in the French works, to which I shall refer later on.

In my early engineering work I had some experience of the evil results of borings, on works in progress close on fifty years ago. I was in charge of the construction of the Albert Dock, which was being made for the Hull Dock Company. We had to build a long lock 80 feet wide, on what appeared to be a perfect foundation of about 40 feet of boulder clay, nearly as hard as rock, and quite impervious to water. When the excavations for the lock had nearly reached their ultimate level we were suddenly drowned out one night by an outburst of water in the excavation. Where the water came from it was impossible to say. More pumps were put up and the area excavated was divided into many small compartments by sheet piling. In the meantime the ground settled in and around the excavation, showing that the water was bringing up material from below. In time we were able to free some of the compartments from water. In one of them, on a clean surface of dark boulder clay, I saw a small hole about 2 inches in diameter full of small grains of white chalk and sand. It was evidently a bore hole, one of many which had been made by rival promoters before the bill for the dock was passed. In the night a jet of water burst up through the bore hole, bringing with it large quantities of clean yellow sand from a bed on the surface of the chalk. This we proved by making a fresh boring through the boulder clay to the chalk. More than one of these borings was no doubt discharging water into the works, and the site had to be abandoned and the dock made shorter to provide a new site for the lock. This incident shows what trouble a few 2-inch borings may bring about in the neighborhood of water-bearing strata.

No doubt extraordinary precautions would be taken in making the proposed borings referred to by M. Sartiaux. But to make a number of borings beneath the sea is to take quite an uncalled for risk. If control of one boring in a tunnel were lost, and the sea-water tapped, the work might have to be abandoned.

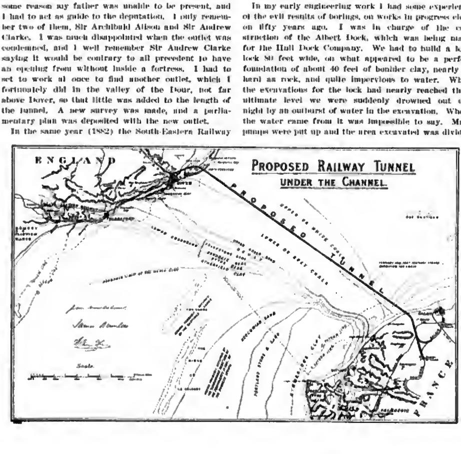
Where the chalk is 500 feet thick to the east of the outcrop, no borings outside the finished work would be necessary, and with six miles less of tunnels to make the risk of meeting water would diminish.

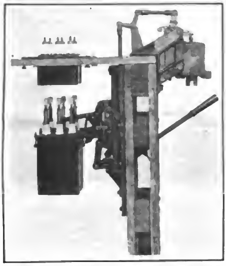
In settling the line for the tunnel we have to consider on what line will an error in our geological calculations be of least moment in our tunneling operations. The French company's marine and geological survey was made with care and precautions such as were probably never before taken. As long as it deals with the surface of the sea-bottom the reports and accompanying plans and sections probably tell us a true story on which we may rely. But when we pass from the surface of the sea-bed to the strata beneath we go from facts to conjectures. A longitudinal section down the center of the Channel shows the chalk from where it begins, at the outcrop of the gault, dipping at first rapidly beneath the sea, the dip gradually diminishing as we go eastward. Now the part of the section in which error is most likely to be found is in the curve which denotes the base of the chalk near the outcrop. For the curve showing the base of the chalk depends not only on the position of the line on the map, which shows the junction of the chalk and the gault, which is probably in the main correctly plotted, but also on the line which shows the junction of the two lowest beds of chalk of the French geologists (Craie de Rouen and Craie de Moyenne). It would be very rash to take this last line as other than approximate; yet all it could tell us, if it were correctly plotted, would be the dip of the base of the chalk close to the sea-bed; and even to get at that we should have to assume the thickness of the Craie de Rouen from its ascertained thickness on the two coasts. Of the dip a short distance below the sea-bed we really know nothing, and the curve indicating it must be imaginary. If the tunnel is to follow the lower beds of chalk it will have to be near this curved line, and any variations in the curve will necessitate deviations in the line of the tunnel, so that its length might be largely increased. This continual deviation would add largely to the difficulties of construction. Again, the lower the beds in which the tunnel is placed, and the nearer to the outcrop of those beds, the greater will be the risk of water finding its way along the planes of bedding from the outcrop.

As we pass from the outcrop of the chalk and the gault in an easterly direction along the Channel, the chalk increases in thickness. On the Fan Hole-Sangatte line it is 480 feet thick, double the thickness it is on the Shakespeare Cliff line. This was conclusively proved by the borings made by my father. An error which would necessitate a considerable deviation in the Shakespeare Cliff line of tunnel would not affect that on the Fan Hole-Sangatte line, where there is the ample margin for error of 250 vertical feet.

The only reason which has been given for taking the tunnel under the shore line to the west of Dover is, that by so doing it is supposed that it can be made wholly in the lowest or grey beds of chalk. It is asserted that no water, or very little, will be found in these lower beds. Now what are the facts? We are told that little water was found in the heading from Shakespeare Cliff. I cannot speak from personal knowledge as I did not visit that work. In the headings driven at Sangatte, in the corresponding beds in France, water was met with flowing from fissures at the sides and bottom, and not confined to one place, but throughout the headings. The quantity which I saw was not large, the largest spring, perhaps, thirty gallons a minute, but it was enough to prove that these beds are not impermeable.

(To be continued.)

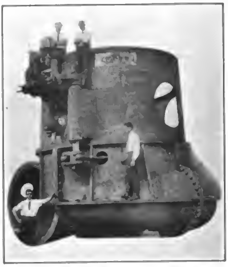




Triple pole, single-throw, 2,500-volt, 300-ampere oil switch with solenoid operating mechanism and disconnecting device.

Gatun Hydroelectric Development for the Panama Canal

How the Surplus Water of Gatun Lake will Furnish Light and Power for the Panama Canal and Railway



Thirty-six hundred horse-power Francis turbine for the Panama Canal hydroelectric station at Gatun spillway.

The permanent supply of electric energy for the Panama Canal is generated in the Gatun hydroelectric station, which is located at the Gatun spillway dam. The tremendous water storage in the artificial Gatun Lake, fed by the Chagres River, not only carries vessels the greater part of the way across the Isthmus on a level about 85 feet above the oceans, and provides water for raising and lowering them gently through the Gatun, Pedro Miguel and Miraflores locks, but it also has afforded an excellent opportunity to generate electric current for lighting the canal, for operating the gigantic gates and other locking machinery, and for the locomotives towing ships through the locks.

Electric current will likewise be used for coal handling plants at both ends of the canal, for machine shops, waterworks, drydocks, and possibly in the future for hauling trains on the Panama Railroad. To insure continuity of service in case of accident, a steam-electric station at Miraflores, erected a few years ago to supply power for construction work, will be ready to pick up the load when necessary.

BRIEF DATA ON THE CANAL.

The extreme length of the canal is about 50 miles, it has a minimum depth of 41 feet, and the channel varies from 300 to 1,000 feet wide. The famous Culebra cut has a length of about nine miles. The crest of Gatun dam has a length of 8,000 feet and an extreme width of 2,100 feet, the height above the normal lake level being 30 feet. There are three double sets of locks at Gatun, one double set at Pedro Miguel and two double sets at Miraflores. The average lift of each set is 28½ feet, the length of each chamber being 1,000 feet and the width 110 feet. The time required for the passage of vessels through the locks is about three hours, and through the canal from ocean to ocean eight to ten hours.

The width of the Canal Zone is 10 miles, and it has an area of 436 square miles. More than 40,000 men have been employed in building the canal, and over 200,000,000 cubic yards of earth have been excavated. It is estimated that $375,000,000 will represent the total cost of this mammoth project.

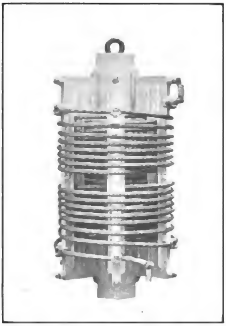
POWER AND DISTRIBUTION EQUIPMENT.

The complete equipment for the power and distribution system on the canal comprises the 7,500 kilowatt, 2,200-volt hydroelectric power plant at Gatun; the 4,500-kilowatt, 2,200-volt Curtis turbogenerator electric power plant at Miraflores for emergency; a double 44,000-volt transmission line across the Isthmus, connecting Cristobal and Balboa with the two power plants; four 44,000/2,200-volt substations, stepping down at Cristobal and Balboa, and up or down at Gatun and Miraflores, depending on which of the two plants is supplying power; thirty-six 2,200/240-volt transmission stations for power, traction and light at Gatun, Pedro Miguel, and Miraflores locks; three 2,200-220-110-volt transformer stations for the control boards at the locks; and stations at Cristobal and Balboa for the coal-handling plants, machine shops and drydocks.

The Gatun hydroelectric station has a capacity of 6,000 kilowatts, and provision has been made to increase this to an ultimate capacity of 12,000 kilowatts, should this amount of power be required later for the operation of the Panama Railroad, the three outlet pipes in the dam having been installed along with the original pipe lines.

OPERATING HEAD AND INTAKE.

The gross head available from Lake Gatun to mean tide level of the Pacific Ocean varies from a maximum of 91 feet in the extreme flood times to a minimum of 70 feet, to which level the lake may possibly drop toward the close of the dry season. The plant is designed consequently to develop the full water output when operating under an effective head of 75 feet. For three or four months of every year there is absolutely no rainfall on the Isthmus; and during this period, it is desirable to conserve the water to as great an extent as possible. Maximum efficiency was, therefore, demanded for the apparatus of both the waterwheel and generator manufacturers.



Current limiting reactance with concrete core, 25-cycle, 42-kilowatt, 64-volt, 656-ampere, Gatun hydroelectric installation, Panama Canal.

Water is taken from Lake Gatun through passages 12 feet wide, fitted with wrought iron racks 29 feet 7 inches high to prevent trash from entering the pipe lines. The water is admitted into the pipe lines through three 10-foot 6-inch diameter head gates. These gates are of massive cast-iron construction, the seats where water tightness is required being made of bronze.

DETAILS AND OPERATION OF THE GATES.

Each gate is equipped with two steel stems for raising and lowering. These stems are fitted with bronze nuts working in roller thrust bearings, and the nuts are fitted with steel bevel gears arranged to be operated by a 15 horse-power, 220 volt, alternating current motor with a speed of 750 revolutions per minute. The motor is placed between the stems and has shaft extensions on each side that carry two bevel pinions arranged to engage the bevel gears on the stem nuts. The stands which carry the stem nuts are equipped with hand operating mechanism, arranged to be disconnected when the gate is operated electrically.

The gates are equipped with automatic control devices, consisting of a limit switch geared to one of the gate stems and a float switch actuated by the water in the pipe. The action of the control is as follows: The gate being closed and the pipe line empty, the gate motor switch is closed at the power house, which starts the motor and begins opening the gate. When the gate has opened a sufficient distance to fill the pipe line in about five minutes, the limit switch opens the circuit and stops the motor.

The gate remains in this position until the pipe line is filled and the water rises in the 36-inch diameter air vent just below the gate, when it actuates a float switch and again closes the motor circuit, thereby causing the gate to be opened fully, when the limit switch again operates to prevent over-travel. The gate is closed by reversing the main switch at the power house, which causes the motor to operate, the limit switch again stopping the motor when the gate has reached the closed position. In case the electric power should fail, the gates can be hand-operated by two men.

THE INTAKE PIPE LINES.

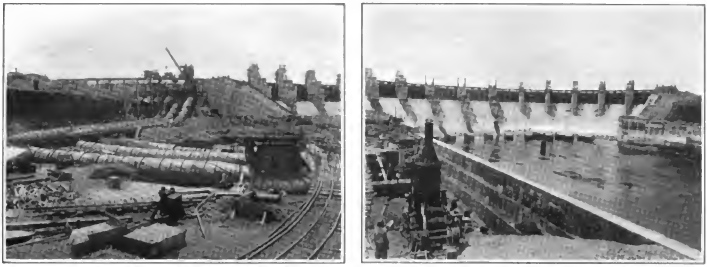
Each of these gates is bolted to a pipe line 10 feet 6 inches in diameter with an average length of 420 feet. The pipe lines are made of ⅝-inch steel plates in courses 8 feet long, each course being made of three sheets to form the circumference. The center of each course is fitted with a 3-inch by ⅜-inch Z bar ring, which is also made in three sections. After the pipe was riveted together at the plant, the outside was covered with a layer of reinforced concrete to prevent rust.

The pipe lines are led down in the rear of the power house on a uniform slope from the spillway, and are connected to the turbines in the power house through 90-degree bends having a radius of 70 feet. Each of the pipe lines is arranged for attaching a Pitot tube testing apparatus while its unit is in service, and one pair of portable tubes for taking readings in planes of the pipe at 90 degrees from each other was supplied.

This is accomplished by fitting each pipe with two 6-inch saddle nozzle connections located 45 degrees on each side of the vertical center line of pipe. From these connections there are two Pitot tube supports placed across the pipe at right angles to each other with their thin sections pointing in the direction of the flow of water and fitted with guides for the Pitot tubes. These supports are bolted in the pipes and, while they are intended to remain permanently in the pipe, if desired, they can be removed very readily.

Each 6-inch outlet on the pipe is closed by a gate valve with tongued and grooved flanges that match the base on the Pitot tube apparatus. Each Pitot tube is arranged to measure both the static and velocity heads at practically the same point in the pipe, and readings are obtained by means of "U" tubes containing a colored liquid having a specific gravity of about 1.25. Carbon tetrachloride thinned with gasoline to the proper specific gravity and colored red is usually used for this purpose.

One end of each "U" tube is connected to the static



Panoramic view of the Gatun hydroelectric installation, Panama Canal, under construction, showing pipe lines and turbines erected.

and the other to the velocity side of the Pitot tube, and the difference in height of the colored liquid columns read, from which the velocity of flow in the pipe is calculated. This form of Pitot tube is very simple and reliable, as it does not require compressed air to keep the head within readable limits and, at the same time, the difference between the static and velocity heads is read off directly.

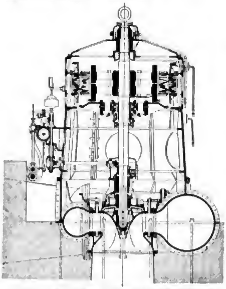
In order to measure the flow in any pipe line, it is only necessary to bolt the Pitot tube base plates to the valve flanges and open the gates, when the tubes can be pushed into the pipes and readings taken. When the test is completed, the Pitot tubes are withdrawn until they clear the gates, then the valves are closed, and the apparatus can be removed.

THE GATUN HYDROELECTRIC STATION BUILDING.

The principal buildings connected with the actual operation of the canal are the hydroelectric station at Gatun spillway; the gate control house at the spillway; the four substations of the transmission system at Gatun, Miraflores, Cristobal and Balboa; and the three-lock control houses. All these structures are designed along simple lines in harmony with the unbroken surfaces of concrete of the adjacent engineering works, and for the same reason are devoid of all modeled ornament; the plain wall surfaces are relieved only by the restrained moldings of the bases and cornices, and architraves bounding the openings. This has the effect of enlarging the scale, or apparent size of the buildings, though they appear dwarfed by their proximity to the large masses of concrete.

The hydroelectric station measures 61 feet by 137 feet and has an extreme height of 74 feet. The building is designed on the unit principle, to admit of future extension, and consists of a single room open to the roof, exposing the trusses upon which is laid the reinforced concrete roof slab, which, in turn, receives the red Spanish tiles. The walls are of poured concrete, 30 inches thick to the level of the crane rails, near the cornice. The exterior overhang of the main roof is 13 feet 2 inches and that of the monitor roof 4 feet 8 inches, the exceedingly large projections having been generally adopted for all the permanent buildings in the zone as a shelter from tropic rains, as well as from the heat of the sun.

Beyond the general use of tile for flooring, and an interior white enameled brick wainscot 14 feet high, to relieve the coarseness of the walls, there is no difference in the finish of the concrete surfaces within and without. The dead surfaces of the concrete or stuccoed walls, which will probably be improved when weathered, are further relieved on the exterior by the red tile roofs. The principal ornamentation is on the underside of the broadly projecting cornice, which is broken up into paneled coffers. A number of these contain light outlets that cast light down on the walls and throw the structure into strong relief at night. The large glass surfaces are attractively broken up into smaller panes. Little wood is used anywhere, but for economy it is utilized in the large side frames and sash, the end frames and sash being of iron.



Cross-section through waterwheel, generator, and exciter, Gatun hydroelectric installation, Panama Canal.

The interior has four principal elevations, namely, a pit for the three 2,500-kilowatt, hydroelectric turbines, a main floor, and two galleries. The turbine pit, with an area of over 2,100 square feet, is located 6 feet below the level of the main floor and is reached by iron stairways descending alongside the turbines. From the pit, other stairs lead down to the storeroom on the north side, and to the air compressor and oil pump compartments at the ends. The pit is lined with white enameled brick, which is both attractive and cleanly. The 14-foot wainscot extends from the main floor up to the first gallery elevation on the south wall of the pit.

Intermediate between the pit and the main floor, and reached by stairs from the latter, are toilets in the southeast corner of the building, giving separate accommodations for white and colored employees. The walls are treated in enameled brick, similar to the turbine pit, and the rooms are equipped with modern fixtures and separate shower compartments.

The main floor divides into two parts, one being partitioned off and devoted to the use of the electrical equipment, and the other forming an uninterrupted passage on the longitudinal axis of the building, terminating with two large entrance doors at either end. Easy access to railway cars is afforded by means of a track which enters this floor from grade through the northwest door, thus giving every facility for handling heavy machinery by the 30-ton electric crane running the length of the building overhead.

Concrete stairways at either end of the building give access to the mezzanine and second galleries, which are devoted to the switchboards, oil switch compartments, reactance coils and other electrical equipment. Two such galleries extend the entire length of the station on the northeast side, and in the south corner are superimposed two smaller ones used as a machine shop and an office, respectively. The sash in the large side wall windows are operated in sections by a hand-gear system, and the continuous bottom hinged sash in the roof monitor are operated by motors.

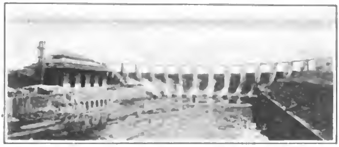
THE THREE FRANCIS TURBINES.

The three 2,000-kilowatt main generating units in the hydroelectric station are each driven by a special 50-inch vertical, single runner, Francis turbine manufactured by the Pelton Water Wheel Company. Each turbine has a maximum capacity of 3,000 horse-power when operating under an effective head of 75 feet, and at a normal turning speed of 250 revolutions per minute. The turbines are located at such a height that the center of the runners is 20 feet above tail water.

The water is discharged through steel-lined concrete draft tubes, which are 74-inch diameter at the discharge from the runners, and increase to an elliptical section of 9 feet by 17 feet at the outlets, which are horizontal, there being a 90-degree bend in the tubes. The linings are made of ½-inch steel plates, which were fitted together in the shop and shipped knocked down.

The turbines are of the spiral case type and are fitted with heavy cast-iron distance rings which carry the generators. The weight of the revolving parts of each generator and turbine is carried on a roller thrust bearing mounted on top of the generator. The turbine

General view of Gatun hydroelectric station and penstocks, Panama Canal, looking south, spillway in the background, June 27th, 1913.



Gatun spillway dam, looking south from bridge, showing fourteen crest gates, Ogee dam and Baffle piers; hydroelectric station on left.

is so designed that the runner exerts an upward thrust of 20,000 pounds when working at full capacity, thereby relieving the thrust bearing of that amount of load.

Oil for the thrust bearing is supplied by a small pump geared to the main turbine shaft, and a tank is provided below the pump to receive the overflow from the bearing. In this way a constant circulation of oil is maintained. As this oil returns to the suction tank, it passes through the lower guide bearing on the main shaft and lubricates it.

The runners of the turbines are made of a special bronze and weigh approximately 7,000 pounds each. They are bored taper and held in place on the lower end of the shaft by means of bronze nuts. The surfaces of the runner vanes are all hand finished to reduce hydraulic losses.

THE GOVERNORS.

The speed of the turbines is controlled by Pelton oil-pressure governors, which are mounted on the distance rings and are driven by bevel gearing from the main shaft. Tachometers are mounted above the governors on supports bolted to the distance rings. The tachometers are directly connected to the governor heads.

The governors are fitted with small electric motors for varying the speed of the main units for synchronizing purposes, and a device is provided on each governor for varying the permanent drop in speed from no load to full load. This can be adjusted for any variation from 5 per cent drop to absolutely constant speed, from friction load to maximum load. The governors are also fitted with hand control mechanism for adjusting the gates independent of the oil pressure.

The wicket gates for controlling the supply of water to the runner of the turbine are steel castings with hand finished surfaces. Each gate has its pivot stem extended upward through a packing gland and is fitted with an operating lever. All the gate levers are connected to the gate ring by means of bronze links, and the gate ring is connected to the governor rockshaft. All the regulating mechanism is therefore outside the turbine case, except the gates themselves. The water passages on each side of the gates are provided with renewable rolled-steel wearing plates.

The pressure oil for actuating the governors is supplied by two Pelton rotary pumping units, driven by 10 horse-power alternating current motors, at a speed of 375 revolutions per minute, each pump being capable of supplying the governors on all three units. The governors work on an open system, there being no vacuum chambers used. The discharge oil from the governors is led into oil sump tanks, from which it passes into the suction of the pumps. Each oil pump is connected to a steel pressure oil receiver with an air space above the oil. The oil sump tanks and pipe connections are installed in duplicate, and valves are provided to enable one set to be cleaned while the other is in service.

GENERATORS AND DIRECT CONNECTED EXCITERS.

The three main generating units are of the vertical revolving field type, each being provided with a direct-connected exciter. The generators are of the General Electric Company manufacture, and are 3-phase, 25-cycle, with a guaranteed continuous capacity of 2,000 kilowatts at 0.8 power factor, 2,200 volts, 250 revolutions per minute, and with an overload rating of 2,500 kilowatts at 0.8 power factor for 2 hours.

The exciters are of 50-kilowatt capacity at 125 volts, each capable of furnishing exciting current for two generators under maximum guaranteed load. Each unit, generator and exciter, weighs approximately 65 tons.

The generators are carried on heavy cast-iron distance rings furnished by the Pelton Water Wheel Company, the stationary armatures being bolted to these rings. The thrust and upper guide bearing support consists of a very rigid iron casting, bolted to the top of the stationary armature.

The thrust bearings are of the roller type, manufactured by the Standard Roller Bearing Company, Philadelphia. These bearings carry the weight of the complete revolving element, consisting of the generator field, exciter armature and turbine runner, which are mounted in this order on a one-piece shaft. The weight thus suspended is 32 tons. The exciter magnet frame is supported by lugs cast on the stationary armature of the main generator.

The exciter is readily accessible through large holes in the distance ring, a platform being provided inside the ring from which the exciter commutator and generator collector rings may be reached.

Provision is made for securing the magnet frame of the exciter to the revolving element of the generator, so that the complete rotating element, together with the exciter frame, is raised at once in disassembling.

For inspection of the roller bearing, it is necessary simply to remove a speed limiting switch from the top of the shaft and the upper half of the bearing housing. There are two guide bearings, one immediately below the thrust bearing, furnished with the generator, and the other above the waterwheel, furnished by the waterwheel builder. The arrangement of the complete unit is shown clearly in the cross-sectional view.

The generators, under official tests, showed an efficiency of 95.1 per cent at 2,000 kilowatts, 0.8 power factor; 94.3 per cent at 1,500 kilowatts, 0.8 power factor; and 92.5 per cent at 1,000 kilowatts, 0.8 power factor. The guaranteed temperature rises of 40 deg. Cent. above room temperature, of 25 deg. Cent. under continuous operation at full load, and 55 deg. Cent. rise after 2 hours run at 25 per cent overload, were met with an ample margin.

All of the apparatus was subjected to the most rigid and minute inspection during manufacture by representatives of the Isthmian Canal Commission. The insulation of all windings was made moisture-proof on account of the extreme climatic conditions on the Isthmus. The revolving field was given a running test at twice normal speed in the testing pit at the factory provided for this special purpose.

REACTANCES.

Current limiting reactances were provided to give 5 per cent reactive drop, at 2,500 kilowatts, 2,200 volts, 3-phase, 25-cycle. While the generator windings are sufficiently rigid to stand the strain of a short circuit under full load, these reactances will reduce the shock on the windings and will also serve to render the operation of synchronizing the machines easier and safe.

MOTOR-GENERATOR SETS.

In addition to the direct-connected exciters, two motor driven exciters are supplied. These consist of a 100-kilowatt, 125-volt, 500-revolution per minute generator, direct connected to a 150 horse-power, 2,200-volt, 25-cycle squirrel cage type, induction motor. They are mounted on a common base plate and provided with three bearings. These exciters can also be used for charging the control battery.

DISTRIBUTION SCHEME.

On account of the great distance, the current is transmitted at a voltage of 44,000 from the power stations to both ends of the canal. The step-up transformers are, however, not located in the power plants, but in substations in their vicinities; therefore, the power plants generate and distribute only 2,200-volt current.

The system of connection throughout employs the double bus, double switch scheme, with provision for disconnecting any oil switch for cleaning or repairs without interrupting the circuit. This system was naturally selected for this station because it was considered the most flexible for the requirement of uninterrupted service, which the engineers of the Isthmian Canal Commission have so carefully considered, though without superfluous complications.

INSTRUMENT AND CONTROL BOARD.

The main switchboard is of the benchboard type, with vertical rear board for relays, watt-hour meters, graphic instruments, and the control battery equipment. The switchboard and all control apparatus were built by the General Electric Company. The space between the front and the rear boards is inclosed by grille work with doors at both ends, and a metal molding extending along the floor and the top of the board gives a finished appearance to the whole. On the top of the switchboard is a second story, for the electrically-controlled generator and exciter rheostats, accessible by means of a ladder inside the structure. The first panel from the left in the benchboard controls the exciters, the next three the generators, and the remaining four the twenty-four feeder circuits. The system of connection is represented by dummy busses of polished copper on top of the bench. The interior view of the benchboard shows the arrangement of operating busses and fuses, potential busses, instrument resistances, and the channel iron risers with distributing tubes, which carry the instrument and control leads to their points of connection on the board.

A generator voltage regulator, transferable to either of the two sets of busses, is installed on a separate pedestal, which also carries the synchronism indicators and clock.

EXCITER BOARD.

As mentioned above, the exciters are controlled from the benchboard, but the electrically operated exciter switches and field switches are mounted on a separate board located so as to make the exciter connections as short as possible. This arrangement eliminates the exciter busses and the main connections from the control board, but leaves the control of the whole equipment in the hands of the operator.

BUS AND SWITCH COMPARTMENTS.

The bus and switch compartments are located on two galleries. On the upper gallery are located the control board near the end of the station that may be extended, the generator reactances, compartment for generator current and potential transformers, and the generator oil switches. From the oil switches, connections are made through the floor to the busses on the gallery below, on which gallery are also the feeder oil switches, and the compartment for the instrument transformers and cable bells. On the main floor, just below this gallery, is the cable vault with racks for the feeder cables.

All compartments are built of concrete with flame-proof doors. The busses and connections are made of solid copper rods of sufficient size to give a rigid construction even where the current is very small. After installation, the busses and connections and all joints are heavily insulated with varnished cambric to make them perfectly safe.

All the 2,200-volt oil switches are solenoid operated, and are provided with mechanism for disconnecting them easily for cleaning or repairs, so arranged that the live parts are completely covered. For the hand-operated switches, a pipe framework supports vertical metal guides which carry the oil switch operating mechanism and slate base forming a section of the switchboard panel. On the guides a lever and toggle mechanism is mounted, by which the oil switch and slate base may be raised and lowered. Above the oil switch, and mounted on the pipe framework, a stationary cast-iron base carries the disconnecting switch studs and insulators. The high-tension leads run to the tops of the disconnecting switch studs, and the bottom of each stud is equipped with contact fingers. On the top of each oil switch stud is mounted a contact blade.

When the oil switch is raised, these blades engage the contacts on the bottom of the disconnecting switch studs, which thus in the closed position form extensions of the oil switch studs. The disconnecting switch contacts are surrounded by insulating shields which prevent accidental contact. When the oil switch is lowered, it is completely isolated from the circuit. When the oil switch is raised, it always goes to a fixed height, where it is latched. An interlock prevents the oil switch from being raised or lowered unless its contacts are open, precluding the circuit being closed or opened by the disconnecting switch. In some instances another interlock makes two single-throw switches a double-throw switch and prevents both switches being closed at the same time.

For solenoid-operated switches, the same form of disconnecting switch is used; but the solenoid is stationary, and the connecting mechanism to the oil switch has a vertical slotted link that allows the oil switch to be raised and lowered without being disconnected from the solenoid mechanism. A mechanical interlock prevents raising or lowering an oil switch while in the closed position.

The complete hydraulic equipment for this installation, including the racks, headgates, pipe lines, Pitot tube-testing apparatus, turbines, governors, and oil pumping units, was designed and built by the Pelton Waterwheel Company; and all the electrical apparatus, including the generators, switchboards, transformers, head-gate motors, limit switches, float switches, accessories, and motors for driving the oil pumps, was designed and built by the General Electric Company. The details of design and manufacture of all this apparatus were subject to the approval of the Isthmian Canal Commission's engineers.

The shipping weight of the material furnished by the Pelton Water Wheel Company, including the auxiliary electrical apparatus purchased by them from the General Electric Company, was approximately one thousand tons.

The "Aquitania" and the "Vaterland."

THE "Vaterland" is the largest ship in the world, both as regards tonnage and dimension. Her gross tonnage is 58,000, her length 950 feet, and her breadth 100 feet. The "Aquitania" has a gross tonnage of 47,000, a length of 901 feet, and a breadth of 97 feet. Steam is derived in the "Vaterland" from forty-six single-ended water-tube boilers, and is generated at a pressure of 235 pounds per square inch. The total heating surface is 203,000 square feet, and the total grate area 3,780 square feet. In the "Aquitania" there are twenty-one large double-ended tank boilers, each with eight furnaces. Steam is generated at a pressure of 195 pounds per square inch. The total heating surface is 138,596 square feet, and the total grate area 3,542 square feet. Her propelling machinery consists of triple-expansion turbines of the Parsons action type driving four screws. Her total ahead horse-power averages 56,000, giving a normal speed of about 23 knots. The engines of the "Vaterland" are triple-expansion turbines of combined impulse and Parsons type driving four screws. The ahead horse-power is about 72,000, giving an average speed of 25½ knots. The full complement of passengers and crew in the "Vaterland" is 6,350, in the "Aquitania," 4,302.

Fluid Motions*

Some Problems Awaiting Solution

By the Right Hon. Lord Rayleigh, O.M., F.R.S.

It is apparent that in dealing with a large and interesting class of fluid motions we cannot go far without including fluid friction, or viscosity, as it is generally called, in order to distinguish it from the very different sort of friction encountered by solids, unless well lubricated. In order to define it, we may consider the simplest case where fluid is included between two parallel walls, at unit distance apart, which move steadily, each at its own plane, with velocities which differ by unity. On the supposition that the fluid also moves in plane strata, the viscosity is measured by the tangential force per unit of area exercised by each stratum upon its neighbors. When we are concerned with internal motions only, we have to do rather with the so-called "kinematic viscosity," found by dividing the quantity above defined by the density of the fluid. On this system the viscosity of water is much *less* than that of air.

Viscosity varies with temperature; and it is well to remember that the viscosity of air increases while that of water decreases as the temperature rises. Also that the viscosity of water may be greatly increased by admixture with alcohol. I used these methods in 1879 during investigations respecting the influence of viscosity upon the behavior of such fluid jets as are sensitive to sound and vibration.

Experimentally the simplest case of motion in which viscosity is paramount is the flow of fluid through capillary tubes. The laws of such motion are simple, and were well investigated by Poiseuille. This is the method employed in practice to determine viscosities. The apparatus before you is arranged to show the diminution of viscosity with rising temperature. In the cold the flow of water through the capillary tube is slow, and it requires 90 seconds to fill a small measuring vessel. When, however, the tube is heated by passing steam through the jacket surrounding it, the flow under the same head is much increased, and the measure is filled in 26 seconds. Another case of great practical importance, where viscosity is the leading consideration, relates to lubrication. In admirably conducted experiments Tower showed that the solid surfaces moving over one another should be separated by a complete film of oil, and that when this is attended to there is no wear. On this basis a fairly complete theory of lubrication has been developed, mainly by O. Reynolds. But the capillary nature of the fluid also enters to some extent, and it is not yet certain that the whole character of a lubricant can be expressed even in terms of both surface tension and viscosity.

It appears that in the extreme cases, when viscosity can be neglected and again when it is paramount, we are able to give a pretty good account of what passes. It is in the intermediate region, where both inertia and viscosity are of influence, that the difficulty is greatest. But even here we are not wholly without guidance. There is a general law, called the law of dynamical similarity, which is often of great service. In the past this law has been unaccountably neglected, and not only in the present field. It allows us to infer what will happen upon one scale of operations from what has been observed at another. On the present occasion I must limit myself to viscous fluids, for which the law of similarity was laid down in all its completeness by Stokes so long ago as 1850. It appears that similar motions may take place provided a certain condition be satisfied, viz., that the product of the linear dimension and the velocity, divided by the kinematic viscosity of the fluid, remain unchanged. Geometrical similarity is presupposed. An example will make this clearer. If we are dealing with a single fluid, say air under given conditions, the kinematic viscosity remains, of course, the same. When a solid sphere moves uniformly through air, the character of the motion of the fluid round it may depend upon the size of the sphere and upon the velocity with which it travels. But we may infer that the motions remain *similar*, if only the product of diameter and velocity be given. Thus, if we know the motion for a particular diameter and velocity of the sphere, we can infer what it will be when the velocity is halved and the diameter doubled. The fluid velocities also will everywhere be halved at the *corresponding places*. M. Eiffel found that for any sphere there is a velocity which may be regarded as critical, i. e., a velocity at which the law of resistance changes its character somewhat suddenly. It follows from the rule that these critical velocities should be inversely proportional to the diameters of the spheres, a conclusion in pretty good agreement with M. Eiffel's observations.[1] But the principle is at least equally important in effecting a comparison between different fluids. If we know what happens on a certain scale and at a certain velocity in *water*, we can infer what will happen in *air* on any other scale, provided the velocity is chosen suitably. It is assumed here that the compressibility of the air does not come into account, an assumption which is admissible so long as the velocities are small in comparison with that of sound.

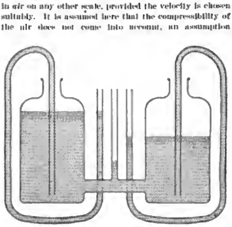


Fig. 1

But although the principle of similarity is well established on the theoretical side and has met with some confirmation in experiment, there has been much hesitation in applying it, due perhaps to certain discrepancies with observation which stand recorded. And there is another reason. It is rather difficult to understand how viscosity can play so large a part as it seems to do, especially when we introduce numbers, which make it appear that the viscosity of air, or water, is very small in relation to the other data occurring in practice. In order to remove these doubts it is very desirable to experiment with different viscosities, but this is not easy to do on a moderately large scale, as in the wind channels used for aeronautical purposes. I am, therefore, desirous of bringing before you some observations that I have recently made with very simple apparatus.

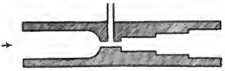


Fig. 2.

When liquid flows from one reservoir to another through a channel in which there is a contracted place, we can compare what we may call the *head* or driving pressure, i. e., the difference of the pressures in the two reservoirs, with the *suction*, i. e., the difference between the pressure in the recipient vessel and that lesser pressure to be found at the narrow place. The ratio of head to suction is a purely numerical quantity, and according to the principle of similarity it should for a given channel remain unchanged, provided the velocity be taken proportional to the kinematic viscosity of the fluid. The use of the same material channel throughout has the advantage that no question can arise as to geometrical similarity, which in principle should extend to any roughness upon the surface, while the necessary changes of velocity are easily attained by altering the head, and those of viscosity by altering the temperature.

The apparatus consisted of two aspirator bottles (Fig. 1) containing water and connected below by a passage bored in a cylinder of lead, 7 centimeters long, fitted water-tight with rubber corks. The form of channel actually employed is shown in Fig. 2. On the upstream side it contracts pretty suddenly from full bore (8 millimeters) to the narrowest place, where the diameter is 2.75 millimeters. On the down-stream side the expansion takes place in four or five steps, corresponding to the drills available. It had at first been intended to use a smooth curve, but preliminary trials showed that this was unnecessary, and the expansion by steps has the advantage of bringing before the mind the dragging action of the jets upon the thin layers of fluid between them and the walls. The three pressures concerned are indicated on manometer tubes as shown, and the two differences of level representing head and suction can be taken off with compasses and referred to a millimeter scale. In starting an observation the water is drawn up in the discharge vessel, so far as may be required, with the aid of an air-pump. The rubber cork at the top of the discharge vessel necessary for this purpose is not shown.

As the head falls during the flow of the water, the ratio of head to suction increases. For most of the observations I contented myself with recording the head for which the ratio of head to suction was exactly 2 : 1, as indicated by proportional compasses. Thus on January 23rd, when the temperature of the water was 9 deg. Cent., the 2 : 1 ratio occurred on four trials at 120, 130, 123, 128, mean 125 millimeters head. The temperature was then raised with precaution by pouring in warm water with passages backward and forward. The occurrence of the 2 : 1 ratio was now much retarded, the mean head being only 35 millimeters, corresponding to a mean temperature of 37 deg. Cent. The ratio of head to suction is thus dependent upon the head or velocity, but when the velocity is altered the original ratio may be recovered if at the same time we make a suitable alteration of viscosity.

And the required alteration of viscosity is about what might have been expected. From Landolt's tables I find that for 9 deg. Cent. the viscosity of water is 0.01368, while for 37 deg. Cent. it is 0.00704. The ratio of viscosities is, accordingly, 1.943. The ratio of heads is 125 : 35. The ratio of *velocities* is the square-root of this, or 1.890, in sufficiently good agreement with the ratio of viscosities.

In some other trials the ratio of velocities *exceeded* a little the ratio of viscosities. It is not pretended that the method would be an accurate one for the comparison of viscosities. The change in the ratio of head to suction is rather slow, and the measurement is usually somewhat prejudiced by unsteadiness in the suction manometer. Possibly better results would be obtained in more elaborate observations by several persons, the head and suction being recorded separately and referred to a time scale, so as to facilitate interpolation. But as they stand, the results suffice for my purpose, showing directly and conclusively the influence of viscosity as compensating a change in the velocity.

In conclusion, I must touch briefly upon a part of the subject where theory is still at fault, and I will limit myself to the simplest case of all—the uniform shearing motion of a viscous fluid between two parallel walls, one of which is at rest, while the other moves tangentially with uniform velocity. It is easy to prove that a uniform shearing motion of the fluid satisfies the dynamical equations, but the question remains: Is this motion stable? Does a small departure from the simple motion tend of itself to die out? In the case where the viscosity is relatively great, observation suggests an affirmative answer; and O. Reynolds, whose illness and comparatively early death were so great a loss to science, was able to deduce the same conclusion from theory. Reynolds's method has been improved, more especially by Prof. Orr of Dublin. The simple motion is thoroughly stable if the viscosity exceed a certain specified value relative to the velocity of the moving plane and the distance between the planes; while if the viscosity is less than this, it is possible to propose a kind of departure from the original motion, which will increase *for a time*. It is on this side of the question that there is a deficiency. When the viscosity is very small, observation appears to show that the simple motion is unstable, and we ought to be able to derive this result from theory. But even if we omit viscosity altogether, it does not appear possible to prove instability *a priori*, at least so long as we regard the walls as mathematically plane. We must confess that at the present we are unable to give a satisfactory account of skin-friction, in order to overcome which millions of horse-power are expended in our ships. Even in the older subjects there are plenty of problems left!

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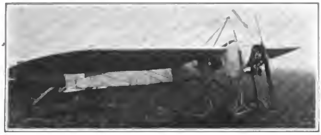
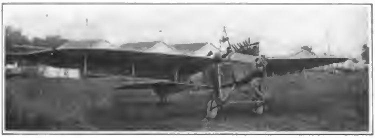
* From a discourse delivered at the Royal Institution on March 20th and reported in *Nature*.

[1] *Comptes rendus*, December 30th, 1912; January 13th, 1913.



Revolving-type motor installation, showing blunt-end at front of fuselage, which is not in keeping with the demands of true stream-line design, and which makes inefficient the center portion of the propeller.



100 h. p., 6-cylinder Mercedes engine in Etrich monoplane. Fuselage with its greatest cross-section about one fifth from the front end, conforming very nearly with demands of stream-line design, and giving greater efficiency to center of propeller.

The Internal Combustion Motor in the Field of Aviation*

Aviation Has Evolved Three General Types of Gasoline Motor

By Howard Huntington, Secretary, Aero Club of America; Chairman Dirigible Committee, Acting Chairman Technical Committee

This paper is divided into four parts. The second, third, and fourth, may be characterized by the words: Past, Present and Future.

The first I shall entitle:

I—Prelude and Early History

SCOPE OF PAPER: BREADTH.

Any paper dealing with aviation must be broad in its scope, and the aero motor will have to cover a large field indeed, for the field of aviation is as long as the East is from the West, and as broad as it is long. It has height and depth, also; not merely in the actual, but figuratively speaking as well; for it opens to us a new and deep philosophy of the proper proportions of things, the enhanced intercommunication and closer relations between peoples, the lessened importance of country and national spirit in the face of the world point of view; the spirit of world-wide peace, and a new meaning to the Brotherhood of Man under the Fatherhood of God.

SCOPE: LIMITATIONS.

And so in presenting a paper of this nature, although confined to the motor in aviation, I must deal largely in generalities, in order to limit myself to forty minutes. You must not expect me to tell you, for instance, what proportion of carbon and nickel has been found best in steel cylinder construction, or what shape of cam is advisable for high-speed valve operation; but I may very likely tell you that there is no critical proportion or shape at all, in these instances, inasmuch as there should be no steel cylinder and no cams or poppet valves, in the make-up of a dependable aviation engine.

MOTOR POWER NECESSARY FOR FLIGHT.

Soaring flight and manual flight are possible eventualities in the path of progress, and prizes for the actual accomplishment of such flight have already been offered in France. But aviation, as an art, would not exist to-day, were it not for the development of the last twenty years, in light-weight engines.

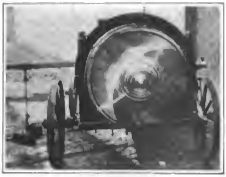
AVIATION'S DEBT TO THE AUTOMOBILE.

Aviation is deeply indebted to the automobile; and it is to the motorcar, rather than to the internal combustion engine, that aviation owes its present success. Flight was not dependent on the gasoline motor, for the Maxim steam engine was light enough to fulfill the necessary requirements for human flight. This engine weighed 1,800 pounds and delivered 363 horse-power—less than 5 pounds per horse-power. It was installed in a life-size flying machine in 1894—Sir Hiram Maxim's multiplane. And it was no fault of this beautifully constructed power plant that this machine failed to fly. (As most of us know, this machine had more head resistance than lifting surface, and was otherwise poorly designed.) The automobile, also requiring light power, bore the burden of the early steps in light-weight development, both in expansion and explosion motors. And the automobile relieved aviation of a great undertaking, when it determined by long experiment and at great cost, which of these two types of prime movers should be universally adopted. The Stanley Steamer is the only American steam car sold to-day. Light weight, great reliability, and long endurance, coupled with high power and economy in the consumption of fuel, are the demands for power in the motorcar. And these are the chief requisites for power in the aeroplanes. Yet lighter weight, yet greater dependability, yet longer endurance, together with higher power, and greater fuel economy—these are of the highest import in the designing of power plants for service in all air-going craft.

THE FIRST MOTOR TO PROPEL MAN THROUGH THE AIR.

Now when the Brothers Wright, in 1901 and 1902, were ready to equip their glider with power, they turned to the automobile industry for an engine. But after investigation at several factories, being of cautious frame of mind, and rightfully exacting, these two Americans, who knew they had invented the controllable aeroplane, decided that they could improve upon the motors offered them; and accordingly they set to work to build their own engines as well as their planes. They discarded the carbureter, as the weakest element in the gasoline engine, and instituted a system of fuel injection. But otherwise it should be noted, they followed the best automobile practice of that time, and by a process of cutting down the weight in every part rather than by a process of elimination of the parts themselves, they produced a standard four-cylinder upright water-cooled automobile

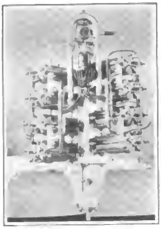
Upright automobile-type motor installation, conforming very well with the demands of true stream-line design.



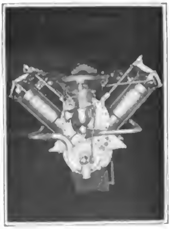
Gnôme air-cooled motor on the testing stand. Beautiful workmanship and balance evidenced by the concentric lines made by the cooling flanges of the cylinders revolving at 1,300 r. p. m.

100 horse-power, six-cylinder Benz, showing narrow aspect to the line flight, which makes for comparatively slight head resistance.

New gyro "duplex" slide intake valve, 80 horse-power motor. The American contender for honors in the revolving air-cooled type.



The 100 horse-power Curtiss motor, two of which are installed on the Wanamaker-Curtiss transatlantic flying boat. Top view.



Curtiss 90-100 horse-power motor. End view, showing water-pump placed on main shaft, thus doing away with extra gears, extra shaft, and extra bearings.

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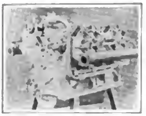
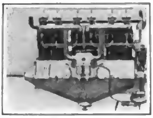
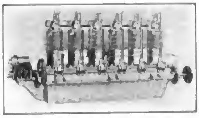
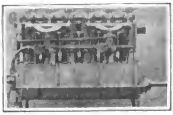
* Paper read before the New Haven meeting, American Society of Mechanical Engineers, May 1st, 1914.


120 h. p., 8-cylinder water-cooled Wolseley aero motor.


100 h. h. p. Mercedes aero engine. The leading German motor.


The Kemp air-cooled motor, showing auxiliary exhausts.


The 120 horse-power British Green engine.

motor, weighing but 7 pounds to the horse-power, which was one half the weight of the best motors of the explosion type to be found at the time. The Brothers Wright in their later motors have followed this upright system, but have come still closer to automobile practice, in adopting the carbureter, which has been brought by the automobile industry to a comparatively high state of perfection.

II—Technical Development in the Past.

THE FRENCH DEVELOPMENT IN REVOLVING ENGINES.

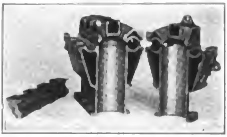
Although America produced the first flying machine, and an American motor was the first to fly, we must admit to our shame that we have left the invention, which we gave to the world, for others to develop. In the years between 1908 and 1912, France produced more in the field of aviation than any other country—or, one might as well say, than all other countries combined. This was chiefly due to their great skill in motor building. I say building rather than designing, because the greatest French motor—the Gnôme—was almost a replica of a poorly built but well-designed American motor, the Adams-Farwell; and of the beautifully designed and well-built Manly motor, which would have been the first to fly in 1903, but for a failure in the launching of the Langley aerodrome nine days before the Wright Brothers' first flight.

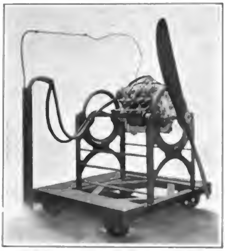
This Gnôme engine constructed by skilled French mechanics proved such a marvel of workmanship, that it soon carried most of the aviation records from America to France.

The first great achievement by the French, however, in the actual art of flying, was the crossing of the Channel in July, 1909, by Louis Blériot. This flight of about half an hour is the more wonderful in the light of present knowledge, in the fact that it was accomplished by an air-cooled engine which, never before or since, has been used for more than a few minutes at a time. The Anzani three-cylinder, single-throw-crank, air-cooled engine deserves honorable mention in the annals of aero-motors, for this flight alone, as it has never been of great service to the cause of aviation. We may dismiss it as an admirable attempt—for it was well built—to cool an engine with air without resorting to force-draught or revolving cylinders.

The real contribution which the French have made to aviation, even greater than their development of the monoplane, is the revolving motor. The Gnôme is a beautiful piece of workmanship. In operation, it is so perfectly balanced that one can count the cooling flanges on the cylinders, though they are revolving about the stationary crankshaft at 1,200 or 1,300 revolutions per minute. In the different models seven, and even nine, cylinders, are placed radially about a single crankcase, which weighs approximately the same as would a crankcase for two similar cylinders, set along on an ordinary crankshaft. This elimination of a long crankcase favors light-weight construction; and, of course, the shortness of the crankshaft is another factor in this respect. The fact that the force of combustion in each cylinder is transmitted to the same crank bearings and even to the same crank pin, does not imply in this case that these parts must be heavier to stand an extra strain; for the strain is, in truth, appreciably less, as the firing order in the cylinders of these engines, having an odd number of cylinders, is 1-3-5-7-9-2-4-6-8-, and 1 again, making an even torque, with nine impulses to every two revolutions of the cylinders. And in an ordinary crankshaft with four or six throws—and the encumbent bearings also to add weight—the explosive force in some of the cylinders must be transmitted against the load, not only useful load, but load partially expended in the friction of the other bearings, and in compressing the charge in the other cylinders at the other end of the crankshaft, through many crank arms and bends. And such crankshaft must be heavy, as well as long, to stand the twisting strain. And so here again, the Gnôme or Manly system is inherently light in weight, through design rather than through cutting down the factor of safety in materials. The cylinders of these motors are of nickel steel, bored out from the solid bar. They are machined and ground inside and out. This type of cylinder makes for light weight. The cooling by air really succeeds in this engine, and the cylinders work at approximately as low a temperature as the average water-cooled engine. This cooling system is an elimination and not a cutting down of weight, and it is a real factor in reliability to dispense with the water-works and plumbing of the usual cooling method. There is no radiator to leak, no hose connection to vibrate loose, no cylinder jacket to fill up with deposit or freeze, no pump to fail, no water to boil or evaporate away. And so for the reasons here outlined, the Gnôme is, by its design, a very light-weight motor. Of all the prominent engines which have won laurels in the field of aviation, the revolving motor is the lightest, weighing approximately 3 pounds per horse-power in the smaller sizes, and 2½ pounds per horse-power in the larger units.

But let us look for a moment at the disadvantages inherent in the revolving type. The charge for the cylinders must enter through the shaft, the crankcase, and the piston end of the combustion chamber. This militates against a variation of the amount of gas admitted, owing to mixing difficulties in the crankcase, with the result that at any speed except the critical speed, the Gnôme is very inefficient on power per unit weight of gasoline. Even at the critical speed, it is not very efficient in this respect. On account of the valve action in the piston head, and because of the complexity of small bearings at the crankpin and on the lower end of the master connecting-rod, it has been found advisable to run this motor at a comparatively low compression. This is also a factor against fuel economy. It is true, too, that a slight but appreciable waste takes place in the power required to revolve the seven-, nine-, fourteen-, or twenty-one cylinders, which are continually rushing into new and relatively stationary air. In some machines, where a long fuselage is used, the nose has to be much more blunt than called for by the demands of true stream-line formation, in order to house this motor, which must be placed broadside to the line of flight. This detriment of greater head-resistance over the narrow upright motor, is of real importance in some applications. Even the V-type motors display but half as much surface for resistance.


Cylinder castings of the Speedwell rotary-valve motor, sawed in cross section to show the water jacket circulation, rotary-valve housings and the cylinder head formation giving an ideal spherical combustion chamber.


Hall-Scott aviation motor on testing stand.

Now, as I have pointed out before, this motor is a beautiful piece of workmanship. There is one questionable element in it, however, which is not a matter of design but of construction. The cylinders are steel, bored out of the solid billet, and while they are of course light in weight, they are not free from a gradual warp, cutting down their lasting qualities, and they require for proper lubrication abnormal amounts of oil, and the oil required is very expensive pure castor oil. Another point of inefficiency in the *design* is found in the automatic intake valves, which do not open as early by suction as they should for the intake of a full charge.

(The Société des Moteurs Gnôme have just now brought out a new model with some improvements, called the Mono-Soupape, or single-valve Gnôme, but as that has not yet won any great laurels in the art, we must not admit it here to our brief discussion.)

Several firms have followed the lead of the Gnôme into the revolving school, and the Rhône with mechanical intake valves has won considerable distinction. But the real difficulty with this type is the waste of oil and the inefficient use of gasoline. Practically all the attempts to follow the Gnôme into the revolving field, with the exception of the American Gyro, have been of French origin; and, although Santos Dumont, who was the first to make a jump or fly at all in France, used a V-type Antoinette motor, it may definitely be said that France's contribution in the field of aero-motors has been the revolving radial type.

THE GERMAN DEVELOPMENT IN UPRIGHT AUTOMOBILE-TYPE ENGINES.

The Germans, with their customary independence and thoroughness, have held that aviation demanded in motive power just what the automobile demanded, only to a more perfect degree. They were, however, too conservative to launch out, as did the French, into radical or radial ideas!

The Austro-Daimler, though built just outside of Germany, was used so extensively by the German aviators in 1912 that it must be mentioned in this category. It was the first motor in Europe to hold its own against the Gnôme. With six cylinders set upright along a strongly built crankshaft, it follows motorcar practice very closely. The design not being inherently light in weight, the cutting down of materials was resorted to, but apparently with no evil effects, except in one particular. Some trouble was experienced with the copper water jackets leaking at the joints, owing partly to vibration.

The Benz, a very efficient engine which developed 100-103 horse-power for seven hours on 0.58 pounds of gasoline and oil per horse-power hour, in an official test, is another example of this type. The Benz has carried to the highest degree the doctrine of dispensing with piping and connections, by arranging for many leads and ducts in the castings.

The most renowned of this German school of water-cooled automobile-type engines is the Mercedes. Here we have a beautifully designed and beautifully constructed engine, along conventional lines, but skilfully cut down in weight to a degree where durability is not impaired. The cylinders, unlike the Gnôme, follow established practice, being cast in a hard gray iron, which lubricates readily and wears well. The length of the connecting-rods is to the length of the stroke in the ratio of 4 to 1, which is a safe and satisfactory relation. Some engines, striving for light weight, cut this down to even 3 to 1, but what they save in shorter cylinder walls and in the length of the rods themselves, is counteracted by the greater friction of the piston due to the greater angle of thrust, and by the fact that the rod and pins must be proportionately heavier.

This Mercedes engine, with radiator and water complete, weighs approximately 4¼ pounds to the horse-power; which means, in a 100 horse-power unit, about 125 pounds more weight than in a Gnôme giving the same power. The new six-cylinder Mercedes is very economical of fuel, using barely ½ pound per horse-power hour. This motor has, in the past year, taken most of the endurance and long distance records away from France. It stands to-day as the most efficient and most respected motor in Europe.

THE BRITISH DEVELOPMENT IN CURTISS V-TYPE MOTORS.

And now following Blériot across the channel, we find a few British patriots flying behind a Green or a Sunbeam "All British made" engine. But the majority put pride in their pockets and pay up the reluctant six or eight hundred pounds required by the Gnôme people for the old stand-by.

The British engines, however, while they have not come into great popularity, are well built, and some of them are admirably designed.

The most interesting *design* among them is the Argyle, which is built in a six-cylinder vertical type. The noteworthy feature in this engine lies in the fact that there are no poppet valves or cams. The intake and exhaust of the gases takes place through ports opened and closed by a sliding sleeve, something after the fashion of the Knight system. There is only a single sleeve, however, which not only operates in an up-and-down direction, but with a twisting motion as well. This engine, weighing about 5 pounds to the horse-power, and developing 130 horse-power at 1,200 revolutions per minute, used, in a test, only 0.48 pound of fuel per horse-power hour.

But the most beautifully *constructed* British engines are the Sunbeam and the Wolseley. These follow the lead of Curtiss in the V-type arrangement of the cylinders, and we might take these as representatives of the highest development in British engines. Their partiality toward this type is evidenced in the fact that a British firm of high repute—the Austin Works—has arranged for the manufacture of Curtiss motors at their works in England.

The Sunbeam engine—of automobile racing fame—is built in sizes up to twelve cylinders and 225 horse-power.

As the number of cylinders and the power increase, engines seem to gain not only lightness in weight per horse-power, but economy in fuel consumption. This monster twelve-cylinder engine weighs complete only 650 pounds, and uses slightly less than 0.48 pound of fuel per horse-power hour.

THE HETEROGENEOUS ASSORTMENT OF AMERICAN MOTORS.

And now with what motor shall we fit across the ocean to America? We hope that the first flight over the waters of the North Atlantic will be under the American flag, and we hope that our machine will be powered with an American motor. The Wright motors we have already mentioned. It is interesting to note that in the early days of the art, in this country, there were many who held that because the two-cycle engine exploded twice as many charges per revolution of the crankshaft, it should have twice the power, or perhaps, allowing for incomplete scavenging, 50 per cent greater power than the four-cycle type. There were in this two-cycle school, the Elbridge of Rochester, the Emerson of Virginia, the Fox from Kentucky, and the Roberts from Ohio. The writer still has hope that the two-cycle principle, which is ideally simple, may some day be worked out to deliver power at least equal to the four-cycle system.

The Manly motor, built in 1901, run for hours in dynamometer tests during 1902, and installed in the ill-fated Langley "Aerodrome" in 1903, is really the first practical aero-motor ever produced. After more than ten years since the unfortunate launching of the Langley aeroplane on the Potomac River, this same motor, with its five revolving cylinders of 5-inch bore and 5½-inch stroke, developing 52 horse-power, was brought to Hammondsport, and flown this spring over the waters of Keuka Lake, in the same old machine, long known in Congress and the press as "Langley's Folly." Mr. Glenn H. Curtiss piloted the machine in this historic flight, and in so doing vindicated the broken-hearted Langley, by proving that he had found the secret of flight, and had built the first motor-driven aeroplane capable of carrying man through the air.

The Gyro is the only successful rotating motor we have produced since the trials of the Manly engine in 1903. In design it would appear to be ahead of the standard Gnôme, having a very ingenious valve-lifting device, and various other refinements. But for some reason it has not attained great popularity, although it has had an American endurance record to its credit. The builders of this motor, the Gyro Motor Company, of Washington, D. C., will bring out shortly a new 80 horse-power single-valve model, and there is every prospect that this motor will be brought to a successful issue. This new Gyro weighs 225 pounds, complete with pumps, magneto and tachometer, and is extremely simple in design, because the old mechanical intake poppet valve in the piston head is replaced by a sliding valve outside the cylinder, which not only simplifies the mechanical part, but takes a great deal of weight from the piston. This is an item of moment, when the actual weight is multiplied by the centrifugal pressure constant.

The Sturtevant, built in Boston, is an example of the automobile-type construction. But unlike the German exponents of this type, the Sturtevant has run into high speed, their newer models attaining their rated power at 1,900 to 2,000 revolutions per minute.

The Maximotor, originally an old L-head automobile-type engine, has been remodeled into an overhead-valve engine, very much after the design of the German Benz. The Kemp is a six-cylinder upright motor with air cooling. As the rear cylinders are blanketed from the air by those in front, this is not a motor for long flight, but it is nicely designed, trim-looking and weighing about 6 pounds per horse-power.

The Hall-Scott, built in San Francisco, is a copy of the Curtiss, and well built. It has many fine flights—that is, fine flights for this country—to its credit.

The Curtiss, built by the pioneer hydro-aeroplane and flying boat builder, is the greatest motor we have. It is the only American motor which is to-day being sold to the armies and navies of Europe.

V-type, and of eight cylinders, with a bore and stroke of 4 inches by 5 inches, it develops 90-100 horse-power at 1,350 to 1,500 revolutions per minute. These engines, built up in lots of a dozen or so at a time, are turned out at the Hammondsport factory at the rate of about two a week. The price of $2,800 compares favorably with any of the French or German engines, except the Benz 100 horse-power, which sells for about $2,600.

The Curtiss engine under load at 1,350 revolutions per minute consumes only 0.52 pound per horse-power hour of fuel. And besides efficiency in fuel consumption, it can claim a weight of 4¼ pounds per horse-power. And, too, it is probably one of the most dependable motors in the world. In the hands of a dozen amateur sportsmen last summer and this past winter, these Curtiss power plants have carried their pilots and passengers an aggregate of 150,000 passenger-miles, without a single casualty. I wonder how this compares with the record of American railroads—a delicate subject, perhaps, to be mentioned down here in New England! It is two of these 100 horse-power motors with which Mr. Rodman Wanamaker is equipping his transatlantic flying machine, which he hopes to send across from Newfoundland to the Azores, Spain, and England this summer.

One of the advantages of the V-design is the fact that eight cylinders can be accommodated on about the same length of shafting as four cylinders in an upright automobile-type engine. While the shaft is not as short, nor the bearings as few, as in the case of the one-throw crank in the radial engines, this system avoids the disadvantages of the rotating air-cooled engines in the matter of extravagant gasoline and oil consumption.

It is interesting to note that it was a V-type engine with which Mr. Curtiss won the Gordon-Bennett International Cup in 1909, in France; and that he is still holding to the same general design.

So much for the past development up to the present time.

III—Influences and Present Tendencies.

THE EFFECT OF LONG DISTANCE FLYING.

As aviation advances step by step, the records are broken with astonishing frequency. With the art but little more than ten years old, we are already contemplating transoceanic and circumterrestrial navigation through the broad highway which leads to everywhere and anywhere.

Until recently, any motor which was light enough per horse-power to lift itself and its load, found a ready market, for to fly was wonderful. And many, indeed, were the accidents due to slipshod assembly of such vital elements as the ignition system. But now, with greater skill acquired in the handling of aircraft, we want great speed. This induces a tendency which has been present since the first flight of the Wright Brothers on December 17th, 1903, when 12 horse-power proved sufficient. Each Gordon-Bennett Cup Race has been won with higher-powered engines than the race of the year preceding. Last summer, in France, this aerial classic was won with a twenty-one cylinder 200 horse-power Gnôme, driving the winner around the five kilometer course at the rate of 125 miles per hour, for one hour.

While the desire for greater speed is exerting an influence for greater and greater power, the most potent reason for larger power at the present time is found in the demand for greater lift and larger machines. In Europe, they are no longer satisfied with two-place and four-place craft; England is building "busses" for six and ten passengers, and Germany and France send up similar numbers in "Aerial Transports," and Russia through the admirable audacity of young Sikorsky, has taken an even greater lead over us, who taught Europe how to fly. This gigantic Sikorsky biplane recently maneuvered over the city of St. Petersburg with seventeen passengers on board, carried in wicker chairs in a roomy cabin with windows, shades, and curtains, if you please! This machine is propelled with 400 horse-power. And now this same young pioneer is building a biplane to accommodate thirty people and travel at a speed of 100 miles per hour with 1,600 horse-power.

As with the railroad locomotive and the steamship, so with the aeroplane. The cry has ever been: greater radius of action, greater speed, and speed variation, and greater carrying capacity; in other words, more power.

THE INCREASE IN DEPENDABILITY.

Along with this demand comes another cry, fully as imperative and insistent. The Wanamaker-Curtiss transatlantic flyer must send out the S. O. S. call for help back to civilization, if the two 100 horse-power Curtiss engines fail to run the course. Every conceivable mishap is anticipated in the design and construction of these engines. And indeed one of the greatest tendencies of the year 1914 is the doubling up of delicate parts.

We find intake and exhaust valves coming out in duplicate. Magnetos are also double on several new designs. Greater care is used in manufacturing methods. The cylinder jackets are welded on to the cylinder ribs by more expensive and better processes. The bearings which are such a vital element in the long life of any piece of machinery are much heavier and of better material.

WATER VS. AIR COOLING.

In the matter of cooling, there has been much division of opinion. The leading aeronautic countries of Germany and France are, again, in this matter, on the opposite sides of the fence. The French motors have been mostly air-cooled. The Esnault-Pelterie and the Anzani have never accomplished very much, because they attempted to cool radial but stationary cylinders, with merely the flow of air past the machine. The Renault, a V-type engine which we have not had time to discuss, succeeds in cooling itself by means of a fan. A rotary fan at one end of the crankcase blows a forced draft through a system of aluminium channels and deflectors to each cylinder. But I say it succeeds in cooling. It also succeeds in adding complication, cumbersomeness and weight, to a degree which makes water cooling more efficient.

The Gnôme and Rhône rotating motors cool well and are inherently light in weight; but at the expense of efficiency in other ways above described.

The Germans, again following the lead of the automobile engineer, have held fast to that which is good, and, with water-cooled engines, have succeeded in taking records away from France, until to-day Germany stands first in aerial development.

It would appear that the aeroplane would find more air about it to cool its engine than would the motorcar. But there is really very little difference; why, in fact, theoretically, there is more air down on the ground than there is above! The aero engine is traveling faster into the new cool air than is the automobile engine, but it is also working at a higher number of revolutions per minute, and under greater and more constant load. And so, I would say that in this important phase of the design of aero-motors, the question is very similar to the same problem in automobile engineering, and will result in the same decision. There are but two automobile companies of any size left in this country with an output of air-cooled cars.

THE IGNITION.

In the field of ignition there seems no reason to be dissatisfied with the present magneto. The only noticeable tendency in this matter seems to be along the lines of doubling up, with two complete and separate systems. Some are adopting the simultaneous spark in two plugs wired in series, to get a more rapid burning of the charge. This had been found in laboratory tests to increase the power of a given cylinder capacity by 3 or 4 per cent.

CARBURETION.

In carburetion, we have taken what the automobile has given us and have found it sufficient unto the day. But with the price and quality of gasoline gradually changing in the inverse ratio, we find a tendency to experiment with carbureters adapted to the use of kerosene and other fuels. Mr. Curtiss has been experimenting with some success in this direction.

IV—The Goal, and a Look to the Future.

STANDARDIZATION INEVITABLE.

At present, in the various problems confronting us, we are in that position where it often appears that the line of least resistance, and therefore of most rapid progress, lies on the other side of the way. But as we stretch out our imaginations and look down the long highway of progress, we find that the paths on each side of the way converge, and there appears to be less difference between them the farther down we look. This may be due to perspective, but it is nevertheless symbolic of the process of standardization. All branches of industry, as the output increases, standardize that output. The aeroplane motor industry will prove no exception to the rule. It will do this in manufacturing methods, and in type and accessories, but not to the same degree of detail as in the case of the automobile motor; for the latter is confined in size and operation to the demands of roadways, limiting size and speed.

FUEL ECONOMY VS. LIGHT-WEIGHT DESIGN AND CONSTRUCTION.

With the great strides of the last decade, and the surety of yet greater strides in the decade ahead of us, we must realize one paramount certainty: the use of aircraft for rapid transit from north to south, and from shore to shore. Except for short-distance flying in run-about machines, this spells the doom of French rotating motor. Even in the new Mono-Soupape Gnôme, which has as yet to prove itself in duration flying, efficiency is claimed chiefly in the matter of lubrication, and it is generally believed that the revolving type can never attain to the gasoline economy of the stationary engine. This means that the advantage of light-weight in the engine holds only for short-distance flying. The weight of the fuel, which must be carried for long flights with the Gnôme or Rhône motors, incurs a weight greater than that of the fuel for the stationary cylinders, and the added weight of the stationary motor itself.

And so we find that for any flight of over four hours' duration, the heavier type of *engine* makes the lightest *power plant*. To cross the ocean with a 200 horse-power Gnôme power-plant, the machine *in toto* would weigh about 1,000 pounds more than with a 200 horse-power Curtiss V-type power plant.

THE AIM IN AERO-MOTOR DESIGNING.

In the next ten years the development must follow along the lines of fuel economy and reliability. The requisites for power in the aeroplane will be the same as outlined under my sub-heading, "Aviation's Debt to the Automobile." But "light weight" will be applied to the whole power plant, including tanks and fuel, and not so much to the engine itself. In other words, the order will be, greater dependability, longer endurance, greater fuel economy, coupled with high power and light weight.

THE THREE GENERAL TYPES COMPARED.

We have discussed three general types. One very naturally inquires which of these is to be the ultimate equipment for the aeroplane. The writer believes that each has a distinct field of its own, and his personal opinions as to the relative merits, and the respective fields of service, of the three general types, may be stated in brief as follows:

In the first place, the upright automobile-type engine, which has attained such signal success in Germany, will always find a market, in sizes up to 150 or 200 horse-power. Its simplicity makes for dependability; and in applications where no fuselage breaks its hole of passage in the air, it will be a favorite on account of its narrow aspect and small head resistance.

The revolving air-cooled type, so successful in France, will find a ready market in aeroplanes of the runabout class, where light weight of *engine* is of first importance, which is usually the case where short radius of action is all-sufficient.

The V-type engine will have the field in the larger machines, where greater radius of action is required, because the revolving-type motor necessitates the carrying of a comparatively greater weight of fuel per ton mile, and the upright automobile-type engine will not be built in large enough units. If the upright motor is to be built in sizes upward of 150 or 200 horse-power, the bore and stroke must needs be larger than has been found practicable, unless an increase in the number of cylinders is resorted to, above the number customary in this type. But six cylinders have been found to be the greatest feasible number which may be placed in a single row along one crankshaft. And as fuel economy is enhanced—above the 150 horse-power size—by an increase in the number of cylinders, rather than by an increase in the bore and stroke, and as the V-type disposition of cylinders admits of twice the usual number of cylinders on approximately the same length and weight of shafting, and with no evil results in the wear and tear of bearings, the V-type motor may be looked to for service in all large machines, and in all other machines designed for long distance flying. A potent reason for my belief in this type for the larger machines is the fact that the stationary type is more economical of fuel than the revolving type. And so, in large machines designed for long cross-country work, the V-type will be actually lighter per horse-power, fuel taken into account, than the revolving power plant. For any flight of over four hours' duration, the heavier V-type water-cooled *engine* will make the lightest *power plant*.

And so we see that these three types, in their respective fields, will undoubtedly persist, each with an ever increasing measure of success.

Of course a great ideal, always before us, is the wireless transmission of electrical power to an electric power plant. The electric motor is so simple that it is easily made dependable. But the electric motor, with its armature and field, is heavy inherently in itself; and this is all too vague a matter to discuss while we are yet awake!

In the gasoline field we have another ideal, which, though not quite so much of a dream, is still only on paper. This is the rotary motor. Distinction must always be made, of course, between the *so-called* rotary motors of the Gnôme type, which I have called rotating, or revolving, motors, and the true rotary engine, in distinction from the reciprocating types. I received an invitation only a day or two ago to look over the designs of a gasoline turbine, of the wizard inventor Nichola Tesla. He claims that he can build a motor of this type to weigh 300 pounds and develop 600 horse-power—one half pound to the horse-power! Dependability is vouched for on the ground that there is only one moving member and three bearings to lubricate. *But*, in the light of present knowledge, the most promising field for development appears to lie in the reciprocating water-cooled four-cycle V-type motor.

NEW FUELS NOT NECESSARY IN THE NEXT TEN YEARS.

New and cheaper fuels will be experimented with, but for the next decade gasoline will be plentiful enough to make it really unnecessary to find something better.

POPPET VALVES WILL GIVE WAY TO SLIDE OR ROTARY VALVES.

The most interesting change that is likely to take place in the design of the reciprocating motor, lies in the probable elimination of the poppet valve. These valves require the inefficient cams to operate them, and about seven out of every hundred horse-power must be expended in opening them against heavy tension springs. The heat at the exhaust valves warps and pits the best tungsten steel valve, and there appears a leakage of compression between it and the valve seat. Wear is a large item in the poppet valve design, and the cams with the pounding push rods are in frequent need of adjustment, and always make a large amount of noise. These valve troubles are of much greater moment in the aeroplane motor than in the automobile, for the former is working at a higher number of revolutions per minute and under a greater and more constant load.

And so, as in the case of the automobile, the demands of long wearing qualities, and of silent operation, will bring about the gradual elimination of the poppet valve. In this development, however, the aero-motor will not follow the lead of the automobile, but the two will go hand in hand, for the automobile is only in the first steps of this process itself. It would really appear that the aero-motor had now practically caught up with the automobile development in internal combustion engines.

The Knight sliding sleeve motor is slowly but steadily gaining a better foothold in the automobile industry, and it may get a slight hold in aviation. But it is the view of the writer that before it triumphs over the poppet-valve engine, another system will overtake both of them. There is a great promise in the rotary-valve engine, if the intake and the exhaust are separate valves. The Mead four-cycle engine, if properly built, will effect a real advance. The writer is at the present time trying to get the owners of the patent to build this engine as it should be built for aviation purposes. It has just now been adopted by one automobile company of high repute as the power plant for all their pleasure cars. This motor will be simple and of few parts. It will therefore be dependable and durable. It will be a trifle lighter in weight inherently than the poppet-valve engine. It will be—already is, in the automobile—a little more economical of both gasoline and oil than either the poppet-valve or the sliding-sleeve motor.

This motor, built in 200 horse-power and 400 horse-power units—eight cylinder and twelve cylinder V-type, respectively—with water-cooling and dual and double ignition, and with large pipes and easy curves in the manifold system, will make a most successful combination.

SAFETY AND MULTIPLICITY OF POWER UNITS.

In closing, I wish to leave one final message with you. It is my earnest belief that aviation will never be as safe a means of cross-country and over-sea transportation as it should be until we discard the idea of hanging our lives up there, in the balance as it were, with one mechanical device as our sole dependence from premature descent, or rather, from premature alighting. No motor, no matter how simple in design, or how perfect in construction, can be 100 per cent reliable. With two motors in the aeroplane, either one of them capable of carrying the machine with the other as dead weight, the safety is much more than doubled. The chance is a very small one that both of these motors will break down at the same moment, or that in such a rare event it should be impossible to find a safe landing. When one motor stops, the careful pilot will steer his ship and passengers to the nearest landing in sight, or have his engineer immediately repair the disabled motor. Machines of the air-going variety will in the future carry two, three, or four—a multiplicity of power units. Russia is already working along these lines. The Sikorsky machine, which carried seventeen people, carried four 100 horse-power water-cooled motors, and in flight, two of these engines were stopped without causing a descent. And report now has it that this young constructor is equipping his 30-passenger craft with four power plants of 400 horse-power each.

CONCLUSION.

May I venture a prophecy? The automobile industry was first an industry in Europe, but to-day nearly nine tenths of the motor car industry is in this country, and it is here that the money is invested. Let us make certain in this matter that "History repeats itself." As the automobile and the motor boat, so the aeroplane. Before this new decade is history, the American motor will lead the world; and with its success, the lead in the *industry* of aviation, the lead in research in the *science* of aviation, the lead in achievement in the *art* of aviation, will all stand to the credit of American genius which gave this invention to Europe and the world; and the laurels in the *sport* of aviation will be brought back to the United States of America.

Some Conditions Inducing Excessive Respiration

It has been pointed out by several investigators[1] that voluntary forced breathing in man may give rise to unpleasant and even alarming symptoms. The outcome apparently depends on a number of modifying factors. As a rule, in a short time after the forced breathing the subject either stops breathing altogether if his respiration is allowed to act involuntarily or he breathes in a very shallow and ineffective manner. Numbness and tingling in the hands and feet are reported to occur; and if the forced breathing has been of considerable duration—two or three minutes or longer—many subjects experience an oxygen want when the subsequent apnea sets in. The lips may turn blue; Cheyne-Stokes breathing may be initiated, and Henderson has called attention further to the occurrence of "light-headedness," polyuria, shivering, muscular weakness and other functional disturbances induced by prolonged forced breathing. He maintains that the symptoms evoked are similar to those of shock, and suggests that death from failure of respiration would probably result from vigorous voluntary hyperpnea for fifteen or twenty minutes.

There are various ways in which excessive respiration—hyperpnea—can be induced in man aside from the purely voluntary manner that has just been referred to. Pain is one of the natural stimuli calling forth hyperpnea. Anger, sorrow, fear and ether-excitement may induce a similar result. All of these phenomena may be attended or followed by what is sometimes spoken of as shock. Henderson, as is well known, has argued that the condition of shock which results in man from extreme physical suffering is, to a large extent, caused by the reduction of the carbon dioxid content of the blood and tissues as the result of the violent and prolonged hyperpnea caused by stimulation of afferent nerves. In contrast with this is the view that the ill effects produced by suffering are the expression of fatigue of the nervous system and of the heart, resulting from the intensity of the sensory irritations. This theory of the etiology of shock has been vigorously combated. We have no desire at this time to enter into a discussion of the nature of this much-debated subject. The underlying facts with respect to the physiologic effects of pain and ether, for example, on the respiration in man ought to be demonstrable quite independent of the interpretation which is put on the consequences thereof.

Hitherto much of the experimental work has been conducted on animals under conditions which approached extremes rarely found in man; or in the case of experiments on man the voluntary forced respiration has been somewhat unlike that which might arise in the exigencies of practice. Dr. A. L. Meyer of the University of Pennsylvania has approached the problem of hyperpnea and acapnia in its possible relation to "one of the most important symptom-complexes in medicine" by a direct study of the effect of moderate pain and of the incipient stage of anesthesia in man. In Haldane's laboratory at Oxford, he determined the volume of air breathed, the respiratory exchange, and the alveolar carbon dioxid pressure on human subjects.[2] The device for securing experimentally the effect of moderate pain, the duration of which could be controlled, consisted in placing a clamp on the end of the little finger. This apparatus could be screwed down firmly and then released. The average pain was, according to the investigator, probably such as might be caused by a severe felon.

Pain of moderate intensity and short duration (two to three minutes) actually produces hyperpnea that can easily be measured. The alveolar carbon dioxid is diminished and the respiratory quotient increased. Ether in suitable low concentration produces hyperpnea in one minute. How vigorous it may become is illustrated by one case in which an air mixture containing 3.3 per cent of ether produced an increase of 92 per cent in the air respired; and on another occasion a mixture of 2.8 per cent produced an augmentation of 66 per cent. The degree of excessive ventilation of the lungs varies in different persons; and with higher concentrations of ether the breathing is diminished. The alleged possibilities of inducing acapnic conditions in man are accordingly established.—*Journal American Medical Association.*

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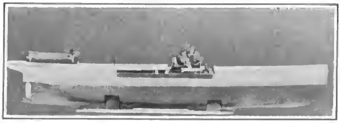
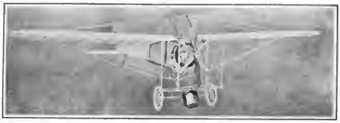
[1] Haldane and Poulton: *Jour. Physiol.*, 1908, xxxvii, 390; Henderson, Yandell: *Am. Jour. Physiol.*, 1909-10, xxv, 310; Respiratory Experiments on Man. *The Journal of American Medical Association*, April 11th, 1914. p. 1,133.

[2] Meyer, A. L.: Hyperpnoea as a Result of Pain and Ether in Man. *Jour. Physiol.*, 1914, xlviii, 47.



The Schilowsky model gyroscope ship, showing the mechanism for stabilization exposed to view.



The Schilowsky model gyroscope as applied to an aeroplane. The model is suspended on pivots to allow it to oscillate freely.

The Schilowsky Gyroscope*

Its Adaptation for Stabilizing Ships and Aeroplanes

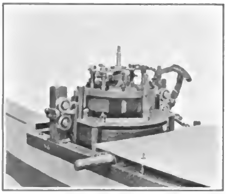
By J. Harris Stone, M.A., F.L.S., F.C.S.

In the May 30th issue of the Scientific American appeared an account of the monorail Schilowsky gyroscope system as applied to trains and motorcars, in other words, to earth-running vehicles. During the last few weeks the Russian inventor has deposited in the South Kensington Science Museum, as presents to the nation, his first completed working models of the gyroscopic invention as applied to the stabilization of ships and of aeroplanes. These two new models with the working monorail train already there, make the South Kensington Science Museum the richest in practical gyroscope appliances in the world; the gyroscope as applied to the stabilization of vehicles on earth, water, and in the air.

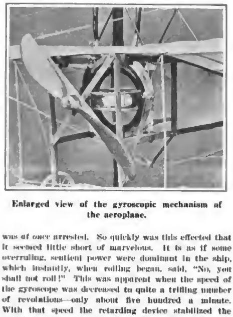
The difficulties to be encountered in stabilizing an earth-running vehicle on two wheels are, from a scientific point of view, greater than those to be overcome in an aquatic or aerial conveyance. A ship and also an aerial machine have already a certain amount of inherent stability, owing to the media in which they progress; and their line of support, of equilibrium, being above the center of gravity, theoretically, it were easier to impart a still greater amount of stabilization to such craft than to a motorcar or train. But practically, the difficulties are still great, and it may be long yet before a ship is constructed which is rigid in all directions except that of direct progression, or an aeroplane made which will always rapidly and automatically right itself when upset by blasts of powerful winds or other causes. Now in a ship, if the movement (other, of course, than that of progression) were confined strictly to what is known as pitching—an upward and downward vibration only—sea-sickness and discomfort would, if not nearly obliterated, be rendered much less prevalent. It is when the pitching of a vessel is combined with the horrid rolling motion that the nausea reaches its zenith, and life to so many of us becomes almost unsupportable. The Schilowsky gyroscope, as applied to ships, is an attempt to minimize, reduce, or even to obliterate the rolling. As a ship afloat is a stable but an oscillatory body, the gyroscope is fitted in a stable manner.

As is shown clearly in our first engraving, the gyroscope is pivoted to the model ship by a system of sliding pivots affixed to it above its center of gravity. If the ship is leaning to either side the gyroscope slides a little along its pivots to the inclined side (port or starboard, as the case may be), and at the same time a suitable arm engages a ratchet device, elastically pivoted to the frame, and this contrivance retards the swinging movement of the gyroscope. M. Schilowsky is the first practical experimenter with gyroscopes to demonstrate that in gyroscopes suspended above the center of gravity, used for stabilizing stable, but oscillatory bodies, it is necessary to bring the troubled gyroscope and the vehicle to their normal positions, and that these results can only be effected by forces just opposite in action to those used for unstable bodies. In place of hurrying up the precision mechanism, a retarding precision device is employed which the inventor calls "antiprecessional." In the model ship at South Kensington it is clearly seen that since the retarding mechanism is put into operation in the vessel, to which an oscillatory motion is given, it restores the horizontal equilibrium of the vessel. Once restored, the gyroscope slides back, and disengagement occurs, leaving the gyroscope ready to repeat the equalizing operation. It is in this device that the peculiar invention of M. Schilowsky is evident.

As in dealing with a ship, we have, as already mentioned, not to stabilize a very unsteady body, like a motor-car or a train: the gyroscope for a ship can be of comparatively trifling weight, and can revolve with comparative slowness. M. Schilowsky is of the opinion, he tells me, that the weight of the ship gyroscope could be decreased to about one half per cent of the total weight of the ship; but I fancy it is extrêmely difficult, at the present stage of the science, to accept this as an infallible datum. I tried the ship model experimentally, and found that it rocked from side to side—port to starboard—just fourteen times before finding rest; that was when set into rocking motion with the gyroscope not in action. When the gyroscope was revolving, but without the side-ratchet contrivance being in gear, the vessel rocked just one half, or seven times. When the gyroscope was revolving, and the side-ratchet apparatus used for exercising the controlling influence on the instrument (in the model on the starboard side of the ship) brought into play, the rocking movement was at once arrested. So quickly was this effected that it seemed little short of marvelous. It is as if some overruling, sentient power were dominant in the ship, which instantly, when rolling began, said, "No, you shall not roll!" This was apparent when the speed of the gyroscope was decreased to quite a trifling number of revolutions—only about five hundred a minute. With that speed the retarding device stabilized the model ship, though not with the same resistive strength as when it was running at two thousand revolutions.



The stabilizing gyroscopic mechanism of the model ship.



Enlarged view of the gyroscopic mechanism of the aeroplane.

From this description it will be apparent that there are attached to the gyroscope, as applied to ships, no heavy or large pendula as are used in the instruments for stabilizing land vehicles, for the weight of the gyroscope itself takes the place of those heavy swinging adjuncts attached to the land instrument.

There is a very prevalent opinion that aeroplanes are very unstable—more so than any other vehicle—but this is hardly correct. In reality, an aeroplane is, like a bird, comparatively speaking, stable, but very oscillatory, and loses very easily its stability when a rolling motion is accelerated. It is therefore most important for the safety of those travelling aerially that the rolling motion should be stayed, and an attempt to attain this object is made by the Schilowsky gyroscope. Were the rolling propensity obliterated, the brains and strenuous attention of the pilot in the aeroplane (which are now largely engaged in overcoming the oscillations of his machine) could be directed solely to overcoming the longitudinal—the up-and-down—movements. In the aeroplane model (a beautiful and exact to scale monoplane of Blériot's) at the South Kensington Science Museum the weight of the pilot is represented by a heavy iron weight, and the gyroscope is proportionately not the weight of a single passenger. When the gyroscope was in action in the model I found it difficult to divert it from the horizontal position, even when pressing with some force on the extreme tip of a wing. Its stiffness was remarkable. The action of the gyroscope as applied to the aeroplane is similar to that used for vessels. Each rolling swings over the gyroscope, sliding on pivots, to the inclined side, and during this movement it comes into contact with the retarding spring, and, consequently, the anti-precessional mechanism is brought at once into play, with the result that the aeroplane is restored to its correct plane of flight. In full-sized aeroplanes the same gasoline engine which drives the fan would also cause the gyroscope to revolve, and the alighting of such a fitted aeroplane on earth or water would therefore also be a matter of ease and great delicacy. Altogether, it is not unlikely that in the next few years we shall witness many marvelous, almost revolutionary, improvements in aeroplanes, especially as regards their safety and carrying capacity, some of which, at any rate, will be due to the use of the gyroscope—an instrument which has only just emerged from the status of a nursery toy.

It may be added that the two-wheel (monotrack) motorcar—figured and described in our issue of May 30th—fitted with M. Schilowsky's gyroscope, has been making many runs about London during the last week or two, to the great delight and wonderment of the public.

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* Reproduced from *Knowledge*.

The Mechanical Efficiency of Muscle

The muscles of the animal body do not produce their work after the manner of a heat engine; but the chemical energy of the substances used up in muscular work is indirectly converted into mechanical work. An intermediate form of energy which appears in the process is that of turgescence or swelling of the muscle fibers. During the operation of a muscle, lactic acid is liberated, which causes the muscle fiber to swell up. The shortening of the muscle fiber, which thus results, is therefore not referable to a combustion process. The combustion or oxidation occurs only subsequently, when the muscle extends to its normal or quiescent state, and serves to remove the lactic acid, the latter being reconverted into the more complex body from which it originated. The efficiency of this chemical engine is greater than that of our heat engines of commerce.

Napier and the Invention of Logarithms*

The Tercentenary of One of the Greatest Labor-saving Devices Known

By Prof. George A. Gibson, M.A., LL.D.

In 1614 John Napier of Merchiston published his "Description of the Admirable Canon of Logarithms." On the title page of the book he is called their "author and inventor," and the words were the simple statement of a fact, because he was the inventor both of the method of logarithmic calculation and of the word logarithm itself.

At the present day it is perhaps somewhat difficult to form an adequate conception of the greatness of Napier's invention; yet it is beyond all question that the invention of logarithms marks an epoch in the history of science. It is generally admitted that Newton's "Principia" is one of the great works that have shaped the course, not merely of modern science in its practical aspects, but of scientific thought in relation to philosophy and theology. But the debt of Newton to Napier, though indirect, was very real, because Newton was essentially dependent on the results of Kepler's calculations, and these calculations might not have been completed in Kepler's lifetime but for the aid that the logarithms afforded. Kepler felt keenly the grievous burden imposed upon him by the older methods, and was correspondingly gratified by the relief that the new means of calculation provided. Without the logarithms or some similar help, astronomical observations could only have been reduced, if at all, with the very greatest difficulty, and the development of modern science might have followed a very different course.

The significance of Napier's invention becomes all the more remarkable when we consider the condition of Scotland during his lifetime. Throughout the greater part of the sixteenth century there was incessant unrest, and such intellectual interests as made themselves felt were predominantly associated with ecclesiastical and theological discussions. Though the foundation of the University of Edinburgh in 1582 increased the number of universities to four, the higher learning could hardly be said to "flourish," even if we allow for the energetic principalship of Andrew Melville. The instruction given in the universities was necessarily of a very elementary kind, since adequately prepared students were not being sent up from the schools, and there was no scientifically minded public to whom appeal might be made. Before Napier, Scotland made not a single contribution to mathematical science, and the appearance, early in the seventeenth century, in Scotland, of a book that at once took rank as one of the great landmarks of scientific discovery, has been a constant subject of remark by the historians of mathematics.

John Napier, the inventor of logarithms, was born in 1550, at Merchiston Castle, near Edinburgh. Such knowledge as we possess of Napier's private life is due almost entirely to the industry of his descendant Mark Napier, whose "Memoirs of John Napier of Merchiston: His Lineage, Life, and Times" (Edinburgh, 1834), is based on careful research, especially of the private papers of the Napier family, and is the source of all modern accounts.

John Napier was the eighth Napier of Merchiston. According to the "Memoirs," Alexander Napare, the first of Merchiston, acquired that estate before the year 1438 from James I, was provost of Edinburgh in 1437, and was otherwise distinguished in that reign. His eldest son, also Alexander, became in his father's lifetime comptroller to James II, and "ran a splendid career under successive monarchs." The origin of these ancestors of John Napier is very uncertain. In the thirteenth and fourteenth centuries persons of the name of Napier were not uncommon, especially in the Lennox. The Merchiston family cherished a tradition that their name was changed from Lennox to Napier by command of a king of the Scots who wished to do honor to one of their ancestors, Donald, a son of an Earl of Lennox. This Donald, it is said, had turned the tide of battle when flowing strongly against the king, and had fought so valiantly that the king declared before all the troops that he had Na Peer.

It is perhaps of more importance that we do not know the correct spelling of Napier's name since many forms of the word are found, such as Napeir, Nepair, Nepeir, Neper, Napare, Naper, Naipper. Apparently the forms Jhone Neper and Jhone Nepair are the most usual with John Napier; the form Napier is said to be comparatively modern.

When John Napier was born his parents must have been very young, not more than sixteen. Of his boyhood and early education very little is known; the only reference on record occurs in a letter of date December 5th, 1560, when he was about ten years old, to his father from the Bishop of Orkney, Adam Bothwell. The letter contains the following passage:

"I pray you, schir, to send your son Jhone to the schuyllis; oyer to France or Flanderis; for he can leyr na guid at hame, nor get na proffeitt in this maist perullous worlde—that he may be saved in it—that he may do frendis efter honnour and proffeitt as I dout not bot he will: quhem with you, and the remanent of our successioune, and my sister, your pairte, God mot preserve eternallie."

It is possible that the bishop had already detected indications of the genius that was later to become so manifest, but it seems to me more likely that the interest shown in the son was intended to stimulate the father to exert himself on the bishop's behalf in certain legal proceedings which form the main subject of the letter.

In 1563, John Napier's mother died, but before her death he had matriculated at St. Salvator's College, St. Andrews, and, by an arrangement made apparently by his mother, he was boarded within the college under the special charge of the principal, John Rutherfurd. Had Napier followed the usual course his name would appear in the list of "Determinantes" for 1566, and of Masters of Arts for 1568; but no trace of it has been found, and the only conclusion to be drawn from its absence is that his residence at St. Salvator's was comparatively short. Principal Rutherfurd seems to have been a man of respectable attainments, but there can be little doubt, that it was not at St. Andrews that Napier acquired his wide knowledge of classical literature or was set upon the path that led to his discoveries and inventions in the field of mathematics.

The influence on his future life of his residence at St. Andrews was, nevertheless, of the most far-reaching character; for it was then that he received an impetus to theological studies that formed throughout his life quite as great an attraction as mathematics in any of its branches.

Theology, of course, bulked largely in the discussions of the sixteenth century, and it seems to have had a fascination for Napier. Various references in his mathematical works can only be explained on the assumption that he could not divert his attention from theological studies sufficiently long to enable him to carry out cherished mathematical investigations. Whatever we may think of the ascendancy that James VI acquired over the Church in Scotland, I am inclined to believe it is James's victory over the Presbyterian party, to which Napier belonged, that compelled Napier to withdraw from the ecclesiastical field and devote himself to his mathematical studies.

It is almost certain, though there is no explicit documentary evidence, that Napier after leaving the university followed the advice of Adam Bothwell, and spent some years on the continent, studying probably at the University of Paris, and visiting the Netherlands and Italy. The extreme probability that, as a member of a noble family, he would be sent to pursue his studies abroad is confirmed by some interesting facts which are mentioned by Mark Napier in his introduction to the posthumous work "De Arte Logistica." Of Napier's travels or of the men under whom he studied or with whom he made acquaintance we have, however, no record; we know that he was in Scotland in 1571.

As the possessor of extensive estates it is fitting that Napier should have turned his attention to the improvement of agriculture. He took keen interest in his property, was inclined to insist upon what he thought to be his rights, but was at the same time eager to promote methods of tillage that offered prospects of better returns. He is said to have carried out careful experiments on "the goodling and manuring of all sorts of field land with common salts, whereby the same may bring forth in more abundance, both of grass and corn of all sorts, and far cheaper than by the common way of dunging used heretofore in Scotland."

Napier's inventiveness was not limited to the peaceful domain of mathematics, but showed itself in devising instruments of war. Mark Napier gives a *fac-simile* of a document preserved in the Bacon Collection in Lambeth Palace, in which John Napier describes some "Secret Inventions, profitable and necessary in these days for defence of this Island and withstanding of strangers, enemies of God's truth and religion." The inventions consist of (1) a mirror for burning the enemies' ships at any distance, (2) a piece of artillery destroying everything round an arc of a circle, and (3) a round metal chariot so constructed that its occupants could move it rapidly and easily, while firing out through small holes in it. Sir Thomas Urquhart asserts that Napier did construct an engine which he tested on a large plain in Scotland "to the destruction of a great many herds of cattle and flocks of sheep, whereof some were distant from other half a mile on all sides, and some a whole mile." It would be hazardous, however, to make any assertion on the strength of Sir Thomas's evidence, and we know too little about these inventions to form any definite conception of them; but there is little doubt that Napier had quite decided mechanical skill.

Of Napier's claims to remembrance, however, the greatest is his invention of logarithms. It has often been remarked that the great discoveries and inventions have always come just when the time was ripe for them, and that if one man had not made the decisive step in advance another would have done so almost as soon. This statement is perhaps less accurate in regard to the invention of logarithms than in respect of many other discoveries; for, with one possible exception, there is no suggestion even that Napier has a rival. The exception is Jobst Bürgi, an ingenious Swiss watchmaker and mechanic. But Napier's "Canon Mirificus" was published six years before Bürgi's "Progress Tabulen"; Bürgi's Tables are very imperfect compared with Napier's; and there is every reason for believing that Napier had formed his conception of logarithms and begun their calculation quite as early as Bürgi—probably much earlier. Besides, Bürgi's work has not had the slightest influence, so far as can be traced, either on the theoretical or on the practical development of logarithms. Napier is therefore entitled to the full credit of an invention which ranks, in respect of its importance in the history of British science, as second only to Newton's "Principia."

The full title of Napier's work, published in 1614, is: "Mirifici Logarithmorum Canonis Descriptio, Ejusque usus in utraque Trigonometria; ut etiam in omni Logistica Mathematica, Amplissimi, Facillimi, and expeditissimi explicatio. Authore ac Inventore, Ioanne Nepero, Barone Merchistonii, etc., Scoto. Edinburgi, Ex officina Andreae Hart Bibliopolae. CIↃ. DC. XIV."

This is printed on an ornamental title page. The work is a small sized quarto, containing 57 pages of explanatory matter, and 90 pages of tables.

An English translation of the "Descriptio" was made by Edward Wright and published in 1616, after the death of the translator, by his son, Samuel Wright. Napier, as stated in Samuel Wright's dedication to the "Right Honourable and Right Worshipful Company of Merchants of London trading to the East Indies," read the translation, and "after great pains taken therein gave approbation to it, both in substance and form." It is therefore perhaps not out of place to give Napier's own account of his invention as that is recorded in "The Author's Preface to the Admirable Table of Logarithms"; it is a slightly modified version of the Preface in the original Latin edition, the modification, however, referring merely to the general purpose and accuracy of the translation:

"Seeing there is nothing (right well-beloved Students of the Mathematics) that is so troublesome to mathematical practice, nor that doth more molest and hinder calculators, than the multiplications, divisions, square, and cubical extractions of great numbers, which besides the tedious expense of time are for the most part subject to many slippery errors, I began therefore to consider in my mind by what certain and ready art I might remove those hindrances. And having thought upon many things to this purpose, I found at length some excellent brief rules to be treated of (perhaps) hereafter. But amongst all, none more profitable than this which together with the hard and tedious multiplications, divisions, and extractions of roots, doth also cast away from the work itself even the very numbers themselves that are to be multiplied, divided, and resolved into roots, and putteth other numbers in their place which perform as much as they can do, only by addition and subtraction, division by two or division by three. Which secret invention, being (as all other good things are) so much the better as it shall be the more common, I thought good heretofore to set forth in Latin for the public use of mathematicians. But now some of our countrymen in this Island, well affected to these studies and the more public good, procured a most learned mathematician to translate the same into our vulgar English tongue, who, after he had finished it, sent the copy of it to me to be seen and considered on by myself. I having most willingly and gladly done the same, find it to be most exact and precisely conformable to my mind and the original. Therefore it may please you who are inclined to these studies to receive it from me and the translator with as much good will as we recommend it unto you. Fare ye well."

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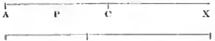
* Paper read before the Royal Philosophical Society of Glasgow, and published in the *Proceedings*.

I do not think one can state more clearly the purpose of logarithms; a more detailed statement necessarily calls for treatment that belongs to the region of mathematics. To those who are only acquainted with logarithms as they are explained in the modern elementary text-books the following points may be of interest:

1. Napier makes no use of a base. The conception of indices in the modern sense of fractional and negative indices was quite unknown in Napier's day and for long after. Algebra was as yet in far too crude a condition to provide a treatment of a logarithm as an index.

2. Napier's treatment is based on the comparison of the velocities of two moving points. Suppose one point P to set out from the point A and to move along the line AX with a uniform velocity V; then suppose another point Q to set out from B on the line BY, *of given length r*, at the same time as P sets out from A and with the same velocity V as that of P on the line AX, but to move, not uniformly, but so that its velocity at any point, as D, is proportional to the distance DY from D to the end Y of the line BY. If now C is the point that P has reached, moving with the uniform velocity V, when Q, moving in the way described, has reached D, then the number which measures AC is the logarithm of the number which measures DY.



Napier had the needs of trigonometry primarily in view, and he usually speaks of BY (or r) as the whole sine and DY as a sine; it will be remembered that in Napier's day the sine was a line and not a ratio as with us.

3. When Q is at B the other point P is at A, so that the logarithm of the whole sine BY is zero. The logarithms of numbers less than BY, say log DY, are positive numbers; if Q were to the left of B then P would be to the left of A and AP would be negative, so that in Napier's system the logarithms of numbers greater than the whole sine are negative.

The circumstance that log 1 is not zero in Napier's system is very awkward. Napier was quite well aware of the disadvantages of taking the whole sine as the number whose logarithm was to be zero, and, as we shall see, afterward suggested the change to a system in which log 1 is zero. He had, however, some good reasons for his first choice, and it must be admitted that for the trigonometry he had chiefly in view the awkwardness is far less than it seems.

4. Napier next establishes the rule that if a is to b as c is to d, then

$$\log a - \log b = \log c - \log d,$$

and from this rule he readily establishes all the rules required for ordinary calculations.

The "Descriptio," besides stating and explaining the rules, gives many examples of the use of logarithms in trigonometrical calculations of a most varied kind; in the course of the work he proves some valuable theorems in spherical trigonometry. The tables give the sines, and the logarithms of the sines and of the tangents of all angles from 0 degree to 90 degrees at intervals of one minute.

It is pleasant that we can state that the value of Napier's invention was at once recognized. As has been mentioned, an English translation appeared in 1616; this translation contains, besides the author's own preface, one by Henry Briggs, geometry-reader (or, as we would say, professor of mathematics) at Gresham College, London. Some interesting statements are preserved of the enthusiasm with which Briggs welcomed Napier's invention. In a letter to Archbishop Usher, dated at Gresham House, March 10th, 1615, he writes: "Naper, lord of Markinston, hath set my head and hands at work with his new and admirable logarithms. I hope to see him this summer, if it please God, for I never saw a book which pleased me better or made me more wonder." Again, Dr. Thomas Smith in his life of Briggs, in the "Vitæ quorundam eruditissimorum et illustrium virorum," says of him when describing his enthusiasm over the "Canon Mirificus: "He cherished it as the apple of his eye; it was ever in his bosom or in his hand, or pressed to his heart, and, with greedy eyes and mind absorbed, he read it again and again. . . . . It was the theme of his praise in familiar conversation with his friends, and he expounded it to his students in the lecture room."

These expressions of Briggs are of special value to us at the present day, because Briggs was a mathematician of great eminence; his appreciation of Napier's work gives us some definite conception, both of the grievous nature of the burden that necessary calculations imposed *on the really competent computer*, and of the relief that the logarithms provided.

Briggs paid his anticipated visit to Napier in the summer of 1615, and there is an interesting story told to Ashmole by William Lilly, the astrologer, of his reception at Merchiston. "I will acquaint you," Lilly narrates in his "Life," "with one memorable story related unto me by John Marr, an excellent mathematician and geometrician whom I conceive you remember. He was servant to King James I and Charles I. When Merchiston first published his logarithms Mr. Briggs, then reader of the astronomy lectures at Gresham College in London, was so surprised with admiration of them that he could have no quietness in himself until he had seen that noble person whose only invention they were. He acquaints John Marr therewith who went into Scotland before Mr. Briggs purposely to be there when these two so learned persons should meet. Mr. Briggs appoints a certain day when to meet at Edinburgh; but, failing thereof, Merchiston was fearful he would not come. It happened one day as John Marr and the Lord Napier were speaking of Mr. Briggs, 'Oh! John,' said Merchiston, 'Mr. Briggs will not come now'; at the very instant one knocks at the gate, John Marr hasted down and it proved to be Mr. Briggs to his great contentment. He brings Mr. Briggs into my lord's chamber, where almost one quarter of an hour was spent, each beholding other with admiration, before one word was spoken. At last Mr. Briggs began, 'My Lord, I have undertaken this long journey purposely to see your person, and to know by what engine of wit or ingenuity you came first to think of this most excellent help unto astronomy, viz., the logarithms; but, my Lord, being by you found out, I wonder nobody else found it out before, when, now being known, it appears so easy.' "

Napier and Briggs must have been congenial spirits, for Briggs spent a month at Merchiston, returned for a second visit in the following summer, and intended to make a third visit in the next year; but Napier died before Briggs was free to set out for the north.

At the first visit Napier and Briggs discussed certain changes in the system of logarithms. In a letter to Napier before the first visit, Briggs had suggested that it would be more convenient, while the logarithm of the whole sine was still taken at zero, to take the logarithm of the tenth part of the sine as a power of 10, and he had actually begun the calculation of tables of his proposed system. Napier agreed that a change was desirable and stated that he had formerly wished to make a change; but that he had preferred to publish the tables already prepared, as he could not, on account of ill health and for other weighty reasons, undertake the construction of new tables. He proposed, however, a somewhat different system from that suggested by Briggs, namely, that zero should be the logarithm, not of the whole sine but of unity, while, as Briggs suggested, the logarithm of the tenth part of the sine should be a power of 10. Briggs at once admitted that Napier's method was decidedly the better, and he set about the calculation of tables on the new system, which is essentially the system of logarithms now in use.

In an "Admonition" printed on the last page of some (not of all) of the copies of the "Canon Mirificus," in a passage of the English translation, and in the dedication to the "Rabdologia," Napier refers to the change of system, but does not state explicitly the share Briggs had in it, though in the dedication he speaks in the heartiest terms of "that most learned man, Henry Briggs, public professor of geometry in London, my most beloved friend."

The copy of the "Canon Mirificus" in the Hunterian Museum of Glasgow University has the "Admonitio." On the title page is written, "Nathan Wrighte of Englefield." Can this be a relative of Edward Wright?

Unfortunately, Dr. Charles Hutton, in the excellent history of logarithms prefixed to the early editions of his Mathematical Tables, gives a version of this story that charges Napier with the intention of belittling Briggs's services, and of allowing no one but himself any credit in the improvement of the original system. It is very difficult to understand how Hutton could come to write as he did, especially as he has no justification in a single recorded word of Briggs himself. Briggs never to his last day spoke of Napier except in terms of the warmest affection, and never showed the least trace of a feeling that Napier had withheld from him any recognition such as Hutton demands. The friendship of Napier and Briggs was almost ideal in its sincerity and warmth, and Hutton's allegations are much to be regretted, occurring as they do in a work that has a deserved reputation for its general accuracy and wide knowledge of mathematical history.

The "Canon Mirificus" gave no account of the method by which the logarithms had been calculated. Napier there states that he prefers to show their use "that the use and profit of the thing being first conceived, the rest may please the more, being set forth hereafter, or else displease the less, being buried in silence. For I expect the judgment and censure of learned men hereupon, before the rest, rashly published, be exposed to the detraction of the envious." Napier did not himself publish any account of his method of calculating logarithms, but in 1619, after his death, his second work on logarithms, "Mirifici Logarithmorum Canonis Constructio," came from the press of Andrew Hart under the editorship of Briggs, and with a preface by Robert Napier, the second son of his second marriage. In the preface Robert Napier notes that in the book logarithms are called "artificial numbers" because his father "had this treatise beside him composed for several years before he invented the word Logarithmus." It is interesting to observe the cordiality of his reference to Briggs; "the whole burden of the business seems to have fallen on the shoulders of the most learned Briggs, as if it were his peculiar destiny to adorn this Sparta."

Robert Napier appears to have been his father's scientific executor; among his papers was found a copy of a treatise by his father on Arithmetic and Algebra which bears the title, in Robert Napier's handwriting: "The Baron of Merchiston his Booke of Arithmeticke and Algebra. For Mr. Henrie Briggs, Professor of Geometrie at Oxfoorde." Whether this treatise was ever sent to Briggs is not known; it was edited for the Bannatyne Club by Mark Napier, and published in 1839 under the title "De Arte Logistica."

"The whole burden" of calculating the new system of logarithms did in a very real sense fall on the shoulders of Briggs, and he devoted to the work conspicuous ability as well as unflagging zeal. Although this is not the occasion for an appreciation of Briggs, it may not be out of place to mention that the Simson collection in our University Library possesses a copy of Briggs's "Arithmetica Logarithmica" of 1624 with this inscription on the first blank leaf: "Hunc mihi donavit Henricus Briggius Anno 1625"; on the title page is the name Rob: Naper, and below this name is written in Simson's well-known hand

Rob: Simson, MDCCXXXIII.

I do not know how this copy came into Simson's possession, but it is gratifying to have this tangible testimony to the good feeling that subsisted between Briggs and Napier's son.

The earliest publication of logarithms on the continent was in 1617, when Benjamin Ursinus included in his "Cursus Mathematicus Practicus" Napier's canon of 1614, shortened two places. It was through this book that Kepler was aroused to the importance of Napier's discovery, though he had previously seen but not read the "Canon Mirificus." His first hasty glance at the "Canon Mirificus" only led him to express himself in somewhat disparaging terms of the author—*Scotus Baro cujus nomen mihi excidit;* but when he had once studied the new method his enthusiasm was akin to that of Briggs. The dedication of his "Ephemeris" for 1620 consists of a letter to Napier dated from Lintz on the Danube, July 28th, 1619. He was not aware that Napier had been then dead for more than two years. In the letter he states that he had used Napier's logarithms in the construction of this "Ephemeris" and therefore, of right, dedicated it to the "Illustrious Baron." In 1624 Kepler published a table of Napierean logarithms with certain modifications and additions. It is perhaps worth noting that by comparing a letter from Kepler to Peter Criiger with a statement made by Anthony Wood in the "Athenæ Oxonienses" about a visit of Dr. Craig, son of the feudist Sir Thomas Craig, one may reasonably infer that Napier was on the track of his logarithms as early as 1594.

This is not the occasion on which to pursue the history of Napier's logarithms. The credit of the invention is justly due to Napier and to Napier alone, but it would be very unjust to forget or to minimize the unique share that Briggs took in the promulgation of the logarithms. The tables in use at the present day are not those of Napier, but those of Briggs, supplemented by those of Adrian Vlacq. Briggs seems to have been a man of the finest type, learned, able, and unselfish; it is only the merest justice to rank him alongside Napier in the history of the invention and calculation of logarithms.

Napier's conception of the logarithm cannot fail to suggest to the student of mathematics Newton's treatment of the fluxional calculus; not that Newton borrowed from Napier, but that the fundamental ideas of both are so much alike. The great generality of Napier's conception has been more clearly understood in recent years, and there is a strong tendency, at least so far as the advanced stages of mathematical study are concerned, to return to a definition of the logarithm that is equivalent to that of Napier.

In the course of his illustrations of the uses of logarithms Napier had frequent occasion to discuss trigonometric theorems, and the latest historian of trigonometry, Dr. A. von Braunmühl, estimates Napier's work in this connection to be of the highest value. Napier, he considers, completely reorganized spherical trigonometry and enormously simplified the treatment of nearly all the trigonometrical formulæ.

Another achievement of Napier should be mentioned here, namely that, though he did not introduce decimal fractions, he did introduce the decimal point, and showed, in the "Constructio," the perfect simplicity and generality that attended its use. The decimal point is one of those simple devices that we take for granted but that needed a genius to invent; many years elapsed before its use became quite general.

John Napier died on the 3rd of April, 1617, and was buried in the church of St. Cuthbert, Edinburgh. It is often stated that he was buried in St. Giles's, but it may now be held as established that it was in the church of St. Cuthbert—the church in which he was an elder—that his body was laid.

David Hume ("History," vol. vii, p. 44) casually refers to Napier as "the person to whom the title of a GREAT MAN is more justly due than to any other whom his country ever produced." Even though this judgment be challenged—and it is hard to decide who is most worthy of such an honorable title—every competent critic will concede that Napier's influence on the development of mathematics and its manifold applications in modern life was profound and far reaching. A man of the highest culture, well versed in classical and theological learning, he was not exempt from the failings that are characteristic of the age in which he lived; in these he shows his kinship with common folk, and elicits our sympathy rather than our censure. But he was a man of pure and simple life, a sincere patriot, a genuine lover of spiritual religion and not merely an exponent of the particular forms it assumed in the confused theology of his day. In originality of conception and depth of insight he is one of the small band of mathematical thinkers, represented by Archimedes in antiquity and by Newton in more modern times, whose genius consolidated the labors of their predecessors and laid down the lines of future advance.

Though Napier's work was an essential condition of modern industrial development and reacted powerfully on modern thought, his name has little or no place in current text-books of Scottish history. Volumes have been written recording in minute detail the most petty squabbles of the sovereigns whose reign he adorned but never mentioning his name. Yet he is honored wherever science is taught, and he is a man whom every Scotchman should be proud to claim as a compatriot.

Some Further Experiments With Liquid Drops and Globules

Life-like Properties of Inert Matter

By Charles R. Darling, A.R.C.Sc.I., F.I.C.

In the issues of the SCIENTIFIC AMERICAN SUPPLEMENT of April 12th and May 31st, 1913, the author described a number of new experiments with liquids approximating in density to water, with special reference to the formation of spheres, drops, and columns, and the movements of globules on the surface of water. The present article, which is reproduced from our English contemporary, *Knowledge*, is intended to supplement those which have previously appeared and will be devoted to a description of some further experiments with the same class of liquids.

WATER SPHERES IN ANILINE SKINS.

At first sight it might appear a difficult operation to inclose one liquid in the skin of another; nothing, however, could be simpler. A layer of aniline is placed at the bottom of a beaker, and covered with water to a depth of about two inches. A glass tube, of bore about one eighth of an inch, open at both ends, is then inserted in the water, and lowered until the end is submerged in the aniline. (As the tube is open, water will enter it on immersion, so as to stand at the same level as that in the beaker.) On lifting the tube out of the aniline a skin of this liquid adheres to the end; and on raising it further this skin is inflated by the water in the tube, which sinks so as to maintain the common level. In this manner the film of aniline is distended by water, just as a soap-film is blown into a bubble with air. In removing the tube entirely from the water the composite spheres remain clinging to the surface, or may fall through the water to the bottom of the beaker (see Fig. 1). If a ring of wire, about three eighths of an inch in diameter, be dipped beneath the aniline and then withdrawn a flat film will adhere, which may be stretched into the familiar shape of a falling drop by lifting the wire suddenly. Many interesting experiments are possible with these films, which are obtained more readily after the aniline has been in contact with the water for some days.

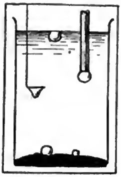


Fig. 1.—Aniline skins enclosing water.

THE "DIVING" DROP.

This experiment illustrates in a striking manner the force with which the surface of a liquid is restored to its normal shape after undergoing distortion. A quantity of dimethyl-aniline is poured onto water to a depth of three quarters of an inch, and a sphere of the liquid, encased in a water skin, formed as described in the previous experiment (see Fig. 2, A). On lifting the tube out of the liquid the sphere falls from the end, and rests on the joining-surface (see Fig. 2, B), where it remains for a few seconds, when it suddenly bursts through the interface, and is projected with some violence downward (see Fig. 2, C), the skin of water having now disappeared. The drop—now composed entirely of dimethyl-aniline—then rises to the top of the water, breaks through the surface, and merges into the liquid above.

This curious behavior on the part of the compound sphere admits of a simple explanation. After resting for a time on the interface the under-part of its skin becomes continuous with the water below, with the result that the shape of the surface joining the two liquids is changed, the sides being now connected to the water-skin forming the upper part of the drop. This is an unstable shape for a stretched surface, which always tends to occupy the minimum area; and hence the skin assumes its normal shape, and with sufficient force to cause the drop beneath it to dive into the water to some depth, although dimethyl-aniline is lighter than water, and tends to float. On the sphere rising and breaking through the interface a similar action, in the reverse direction, takes place, but cannot be seen owing to the sphere losing its identity on entering its own liquid.

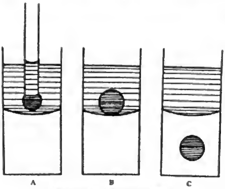


Fig. 2.—The "diving" drop.

"Diving" drops can be obtained by using ordinary paraffin oil instead of dimethyl-aniline; the effect, however, is not so well marked.

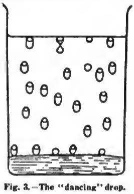


Fig. 3.—The "dancing" drop.

THE "DANCING" DROPS.

When a volatile liquid is heated beneath a layer of water the bubbles of vapor, on leaving the joining-surface and entering the water, tend to carry with them a portion of the liquid below. This may be seen on heating a layer of chloroform about half an inch deep, covered by water to a depth of about three inches. The action, however, is much more striking if *monobrom-benzene* be used, as this liquid possesses a higher boiling-point than chloroform. On heating the liquid the vapor bubbles enter the water loaded with a drop of liquid, the amount detached being such as to make the density of the combined vapor and liquid drops about equal to that of water. On rising the drops enter a colder layer of water, which causes the vapor to contract and partially condense, with the result that the drops sink. On reaching the warmer region below, however, the lifting power is restored, and the drops rise again. The appearance of the drops is shown in Fig. 3, but the chief interest of the experiment lies in the novelty of the movements. Some reach the surface at once, and there discharge the vapor, when the attached liquid falls; others dance up and down with great rapidity; while others, the densities of which are nicely balanced with that of the water, move slowly upward or downward. This simple experiment is at once interesting and instructive, and is one in which actual observation conveys far more than a mere description.

THE "EXPANDING" GLOBULE.

A globule at rest on the surface of water is maintained in equilibrium by the operation of three tensions, viz., water-air, liquid-air, and water-liquid, or interfacial. Any alteration in these tensions will disturb the equilibrium and cause the globule to alter in shape. This is shown in a striking manner by floating a globule of aniline on water and dropping into it a small quantity of quinoline, when the globule will be observed to expand violently in all directions, leaving a hole in the center (see Fig. 4). This action is even more intense if a drop of quinoline be placed on a globule of light lubricating oil, when it will be observed that the quinoline sinks through the globule, without causing any disturbance, until it breaks through the junction of the oil and water, when the globule spreads out with such force as to be broken into several portions. This phenomenon is therefore due to an alteration in the interfacial tension, which now offers less opposition to the pull of the water-air tension on the globule, and hence spreading occurs.

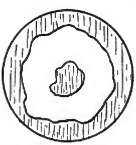


Fig. 4.—The "expanding" globule.

THE "DEVOURING" GLOBULE.

When globules of different liquids are floating on the same water surface a tendency to join together is sometimes noticed, and the same applies to separate globules of the same liquid. This tendency to coalesce with other globules is shown in a marked degree by dimethyl-aniline, and may be utilized so as to give the novel appearance of one globule feeding on another. To show this effect to best advantage, a small quantity of orthotoluidine is poured onto a clean water surface, when it breaks up into a number of active globules. A large globule of dimethyl-aniline is then formed on the surface, which at once proceeds to feast upon the orthotoluidine. The procedure is shown in Fig. 5, which represents (1) the initial stage; (2) the large globule of dimethyl-aniline sending out a protuberance in the direction of the small one; (3) the small globule incorporated; (4) the protuberance withdrawn, causing a recoil which spreads the large globule laterally; and (5) the globule restored to its proper shape, showing streaks due to the orthotoluidine not being perfectly mixed—an operation which takes a short time, after which the globule becomes clear again. The process is then repeated, one after another of the orthotoluidine globules being absorbed until the surface has been cleared, when the "devourer" comes to rest in the center of the surface. It is amusing to observe how the small globules sometimes retreat, as if trying to avoid capture, only to be pursued and made to share the common fate. The movements may be seen to better advantage when the surface is magnified by lantern projection, and resemble in a striking manner certain processes associated with life—such, for example, as a white blood-corpuscle (phagocyte) feeding on microbes. And it is interesting to note in this connection that some of the other movements of globules described by the author in previous issues of the SCIENTIFIC AMERICAN SUPPLEMENT show analogies to the movements of the lower organisms; for example, the pulsation of aniline globules and the motion of translation and subdivision of orthotoluidine; all of which only proves, however, that certain phenomena, usually supposed to be inseparable from life, may be produced with inert substances.

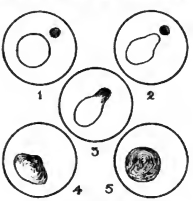


Fig. 5.—The "devouring" globule.

The Price of Labor Expressed in Terms of Food Fuel*

As man is a fuel-consuming machine, it requires no argument to emphasize the importance of knowledge concerning the food-fuel which he needs. It matters little whether instinct is an unerring guide in providing a suitable supply of nutriment for the individual. Unless food is available at a cost within the reach of those concerned, the possibility of inadequate maintenance at once arises. The question of the under-nutrition of the masses or the under-feeding of any group in society, whether it be school children, the indigent sick or the poorest laborers in the community, cannot be solved permanently before the actual nutritive needs of all of these classes are ascertained on an indisputable scientific basis. Only then is it possible to determine if the failure to obtain adequate nourishment is due, in each case, to poverty, or to the lack of suitable food-supplies or to ignorance and perverted judgment in the purchase of the day's ration.

For this reason, various "standards" have been proposed by physiologists and chemists for daily dietaries of persons of differing age, sex and occupation, and in different conditions of life. In general, these estimates have been based on two distinct methods of ascertaining the suitability of a ration. By the one, the quantities of food actually consumed by individuals or known groups of persons have been noted. The other method consists in determining, by special metabolism experiments, the actual physiologic demand for food. This furnishes information concerning the needs of man in maintaining a nutritive equilibrium under selected conditions of activity rather than what he would eat if given the freedom of choice. This method, being the more laborious and difficult mode of investigating dietary needs, has hitherto been employed less frequently in experimental inquiry than has the statistical method.

On the basis of the former procedure, in which the proportions of foodstuffs assumed to be needed are inferred empirically from those consumed in observed cases, nearly all of the widely quoted dietary standards have been established. Any one who hopes to interpret or employ them rationally must bear certain fundamental principles of nutrition in mind. The requirements of the body in terms of food-fuel or energy depend on the way in which food is used to build the organism and repair its waste, and above all on its heat- and power-yielding quality, particularly through the activity of the musculature. Bearing these facts in mind, it is obvious that the size of an individual is one of the factors which determine the need of food. If vigorous growth is still in progress, the demand of nutrients for new tissue construction may become noteworthy. Chief, however, stand the variations of demand caused by the unlike expenditure of energy in different occupations. The sedentary bookkeeper or seamstress requires a far smaller supply of energy than the wood-chopper or the washerwoman. It is a customary assumption that, because of her smaller average stature and lesser muscular performance, a woman requires on the average eight-tenths as much food as a man for corresponding muscular activity. It has also been assumed that children of different ages consume from three-tenths to eight-tenths as much as the man of the family. Such generalizations have become necessary whenever the food habits of people have been investigated by the observation of food purchase or consumption in entire families.

We shall not go far amiss if we express the current dietary standards, so far as they are based on the preceding mode of estimating them for conditions prevailing in the United States, in terms of the results compiled by Dr. Langworthy of the United States Department of Agriculture, as follows:

Occupation of Head of Family	Fuel Value of Food per Man per Day, in Calories.
Man at very hard work	6,000
Farmers, mechanics, etc.	3,425
Business men, students	3,285
Inmates of institutions, little or no work	2,600
Very poor persons, usually out of work	2,100

Without denying, in any way, the importance and great value of such indirect data, one may frankly designate them as rather inexact. For this reason it is still desirable to check up their indications, whenever possible, by direct measurements of the energy transformations. Numerous results already collected by this method of investigation have given no occasion to question the general validity of the "standards" set by the less accurate statistical method. The latest of such metabolism studies is of particular interest because it was conducted under the conditions of work that represent in some adequate way the daily muscular performances of the persons concerned.[1] The experiments were conducted in the large respiration apparatus of the physiologic institute at the University of Helsingfors in Finland, the carbon dioxid output of the subjects being determined during periods of rest and characteristic activity, and calculated into terms of energy consumed. Making an allowance of 10 per cent for the alimentary waste of food, the gross results were as follows:

Men.	Calories per Day.
Tailor	2,600-2,800
Bookbinder	3,000
Shoemaker	3,100
Metal-worker	3,400-3,500
Painter	3,500-3,600
Cabinetmaker	3,600-4,000
Stonecutter	4,700-5,200
Wood-cutter	5,500-6,000
Women	
Seamstress (by hand)	2,100
Seamstress (sewing machine)	2,100-2,300
Bookbinder	2,100-2,300
Housemaid	2,500-3,300
Washerwoman	2,800-3,700

These interesting figures not only give an impressive confirmation of the energy standard derived by less direct methods of investigation, but also bring into immediate, clear relief the great differences that the various trades and occupations entail. Such facts need to be taken into consideration in institutions in which the inmates are assigned to work as unlike as bookkeeping or sewing on the one hand, and woodchopping or other forms of hard manual labor on the other. Such figures show the obvious physiologic injustice of doling out equal portions of the same ration to all of these persons, especially when free choice is restricted or practically impossible. Furthermore, it should be noted that the data of the Finnish physiologists are based on an eight-hour working day. Any lengthening of this period must affect the expenditure here represented.

It is impossible to determine from the cursory studies that have been made whether the scale of living or "standard of life" is actually much higher here, as has been asserted by some, than it is in Europe. One American authority, the late Prof. Atwater, frankly believed that, considering the body as a machine, the American workingman is more strongly built and has a larger fuel-supply than his European brother. While it is not absolutely proved, it seems in the highest degree probable that the higher standard of living, the better nutrition, the large product of labor, and the higher wages go together. The justification for any propaganda in favor of more liberal standards for dietaries rests in a measure on the truth of this belief. And, speaking aside for the moment, a glance at the figures which we have quoted shows that the proverbial advice to "mind one's business and saw wood" entails no mediocre performance in terms of calories per day.

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* Reproduced from the *Journal* of the American Medical Association.

[1] Becker, G., and Hämäläinen, J. W.: Untersuchungen über die Kohlensäureabgabe bei gewerblicher Arbeit, Skandin. Arch. f. Physiol., 1914, xxxi, 198.

The Flora of Guam has recently been studied by R. C. McGregor, of the Philippine Bureau of Science, who, in addition to the specimens which he took back to Manila, presented the Guam agricultural experiment station with an herbarium representing the results of his collections in the island. One genus and about forty species new to science are included in the collection.

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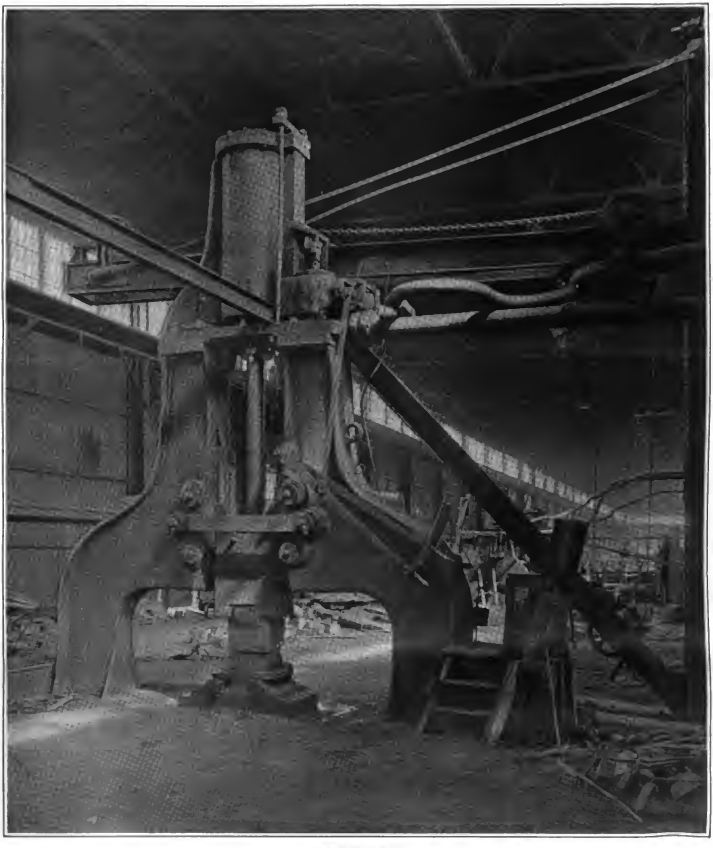

A three-ton hammer.

THE MANUFACTURE OF CRUCIBLE STEEL.—[See page 40.]

The Channel Tunnel and Its Early History—II*

Plans for Direct Railway Connection Between England and France

By John Clarke Hawkshaw, M.A.

Concluded from Scientific American Supplement No. 2010, Page 19, July 11, 1914

I do not attach much value to deductions as to the probable conditions of the beds below sea-level made from observed conditions above the sea-level, for the constant movement of the land waters, from the highest levels to the points where they are discharged into the sea, must produce well-defined drainage channels underground, which need not necessarily exist at greater depths where there may be no such rapid circulation.

Still, as much has been made, especially by the French engineers, of evidence derived from observations in the zones from which water is discharged on land, I will give a few facts relating to them. In France water may be seen to flow in many places from the lower beds of chalk, where they appear in the cliffs between Escalles and St. Pot. I saw water flowing at the very junction of the lowest beds and the greensand. There are some large springs near Escalles, which on the section accompanying the French report (1877) are shown at about 60 feet above the upper greensand. The section shows Lydden Spout in England on the same horizon, but that copious and well-known spring, on the coast between Folkestone and Dover, issues at the top of the so-called "cast bed," about thirty-two feet above the upper greensand, or 46 feet above the gault. Therefore, if this evidence is worth anything it shows that, on the French side, water might be met with largely, 60 feet above the greensand, and on the English side at only 32 feet above it. Thus, if the evidence from the permeability of the strata on land proves anything, it is that a tunnel driven in the lowest beds of chalk must come very near a bed from which large springs are discharged on land, and that it would probably have to pass into this bed.

It has not only been asserted that very little or no water will be met with in the lowest beds of chalk, but also that so much will be met with in the higher beds as to make it impracticable to tunnel through them. Large numbers of wells have been sunk all over the country, and other excavations have been made at all depths and in all parts of the chalk formation, for the purpose of obtaining water, and our knowledge of the mode in which water occurs in that formation is fairly complete.

The following are, I believe, well-established facts on the subject in question:

Solid chalk absorbs a large amount of water, but it parts with it with extreme slowness, so that it cannot be said to be truly permeable. It is only from the fissures which traverse chalk formation and from cavities found along its planes of stratification that water can be obtained. At a variable depth below the surface of the land the body of the chalk is saturated, and such fissures or cavities as may occur there are full of water, not stationary, but slowly flowing from the higher ground inland toward the river valleys and seashore, where the water can find an outlet. Thus, there is a circulation of water underground just as there is above ground in other less porous formations. Moreover, as the streams and watercourses on the surface are independent of one another, so are the underground channels in the chalk.

If in excavating the chalk a fissure is cut across, a certain supply of water may be obtained; if a second fissure is cut through, a further supply may be obtained; and generally it will be found that, if water is pumped from one fissure, it does not immediately diminish the flow from adjoining fissures, and in like manner, if the flow of water from one fissure is checked, it does not necessarily increase the flow from those adjoining. In course of time lowering the water level at any fissure will affect the supply to adjoining fissures, inasmuch as all draw their supply from the same saturated mass of chalk; but as a consequence of the slowness with which chalk gives up its water, unless there is direct communication between two fissures, operations at one do not generally affect the others. Now this property of the chalk is of the greatest importance in carrying out engineering works which require excavations to be made through the water-bearing levels in it, for it enables the engineer to deal with the water in detail. Fissure after fissure may be cut through as long as the water flowing from them leaves a sufficient margin of unused pumping power; as soon as the yield of water becomes so great as to diminish that margin unduly, some of the fissures may be blocked up with temporary or permanent work. Thus it will be seen that, in tunneling through the chalk, a very large volume of water might be dealt with if it entered the work by separate channels. A very large body of water entering at one point might give trouble, and I shall accordingly select some facts from the very large number available to show that from no one area of chalk, even of considerable extent, much less from one fissure, has a supply of water been derived larger than could be easily dealt with, or which at all approaches the volumes which have been dealt with on works completed or now in progress.

At Goldstone Bottom, one of the pumping stations of the Brighton Waterworks, a greater quantity of water was obtained than at any other locality known to me when I dealt with this question in a paper read at a meeting of the British Association at Southampton in 1882. Mr. Easton, the best authority on this subject, kindly furnished me with some particulars at the time respecting these works. There were engines at Goldstone Bottom capable of raising 300,000 gallons an hour, or 5,000 gallons a minute; but it was necessary to make a length of 1,800 feet of tunnels to obtain the required supply. These were at right angles to the fissures, which there, as is so often the case, were at right angles to the shore line. At Lewes Road, another Brighton pumping station, it was necessary to drive 2,400 feet of tunnels to supply pumps capable of lifting 280,000 gallons an hour. Mr. Easton then told me, and this is the important point, that the water in these tunnels was under complete control, so that any one of them could be laid dry at any time of the year.

A work which tested to the fullest our power to tunnel through the wettest parts of the chalk was the Brighton intercepting sewer, for which Sir John Hawkshaw was the engineer. The main sewer is more than seven miles long. The outfall is placed on the coast about four miles to the east of Brighton, and throughout a distance of four and a half miles a tunnel from 9 feet to 10 feet in diameter was excavated in the upper chalk along the base of the cliff, and close to the shore. Being below high-water level, it cut through all the fissures which discharge the drainage of a large tract of inland chalk country. Large fissures were cut through, which I had frequent opportunities of inspecting, and, moreover, of seeing the permanent work successfully carried across them. The greatest quantity of water pumped at one time was 10,000 gallons a minute, or 600,000 an hour. Many other examples might be given, some of much later date, but none so striking as the above. It may be urged that, by going below the levels reached by the above works, more water would have been found; but that by no means follows. The Brighton sewer works must have intercepted most of the land drainage; by going deeper some water stored in cavities below sea-level might have been pumped. But the supply depends, not on the quantity stored, but the rate at which the fissures can deliver it, and the rate at which the chalk can supply the fissures, which we know is extremely slow.

Fissures there are, or there have been, at all depths, but as the circulation is not so rapid in the deeper ones, they are more liable to be choked by sedimentary and crystalline deposits. Deep mines are often very dry ones.

As an example of the water supply obtained from deep down in the chalk, we may take the supply drawn from the London basin. Below London we have a great thickness of both the upper and lower chalk, amounting together to more than 600 feet in places. As this chalk, so far as we know, rests in a basin of gault clay, and rises in continuous beds to form the high ground to the north and south of the London basin, it is in the best position to be saturated with water, and such was the condition before it was made use of as a source of water supply for London and its neighborhood. As the supply from the shallow wells made in the tertiary beds became exhausted, deeper wells were sunk into the chalk beneath, and water was obtained in plenty. But the supply soon ceased to be equal to the demand; the level of the water in the chalk was depressed, so that wells had to be deepened and new adits made to cut new fissures. In 1838 the quantity pumped in London was estimated at 6,000,000 gallons a day; in 1850 the quantity had increased to not more than 12,000,000 gallons a day. In the meantime the level of the water in the chalk had been depressed in some places 50 feet. Thus the larger quantity could only be obtained at a great depth, and by increasing the fall in the fissures delivering the water to the pumps. Now this chalk, from which only a limited supply could be obtained at a given depth over a large area, was connected on all sides with an unexhausted reservoir, at a much higher level, formed by the saturated masses of chalk round the London basin, and yet the water level in it was reduced by a comparatively small amount of pumping.

In the Severn tunnel we pumped 24,000,000 gallons a day, twice the quantity which, when pumped in the London basin, lowered the level of the water in the saturated chalk 50 feet. The Severn tunnel is the longest railway tunnel in England, in all four and a quarter miles in length, and it is the only railway tunnel which can claim to be submarine. It passes for two and a half miles below a tideway where there is a rise of tide of 40 feet and a depth of water of 90 feet in the deepest part of the channels. It passes for a considerable part of its length through the triassic red marl, which has many points of resemblance to chalk. The marl, which lies in horizontal beds, was much fissured, and from these fissures, as well as from the spaces between the planes of bedding, much water was discharged. For some distance at the English end of the submarine part of the tunnel there is only 35 feet to 40 feet of this open-jointed red marl above the brickwork of the tunnel. Salt water flowed freely into the work, and to show how the water channels are disconnected, salt and fresh water have in some cases flowed from adjoining fissures, and the fresh water was allowed to flow for drinking purposes through pipes built into the brickwork. The largest quantity of water and the largest spring were met with in the land portion of the tunnel. The spring referred to discharged 5,000 gallons a minute, and burst suddenly into a heading which had been driven for over 1,000 feet in millstone grit without meeting with any water. If the heading had been driven at a level of 10 feet lower, the spring would have been avoided in the heading, but would have been met with when it was enlarged to the full size of the tunnel.

From the examples I have given it will be seen that engineering works need not be stopped, even by large quantities of water, and from what we know of the chalk and its water-bearing qualities, there is nothing to show that water would be met with in such large quantities under the English Channel as to stop tunneling even in the upper chalk with flints.

As already mentioned, a tunnel from Fan Hole to Sangatte would be 20.8 miles long, and is practically as short a line as can be well obtained. It would be in a straight line, with gradients fixed beforehand, running wholly in the upper part of the lower chalk without flints, with an ample thickness of chalk above and below, and no fear of running out of it, as would be the case near the outcrop on the Folkestone route. If it were worth while, the tunnel could be made from Fan Hole for three quarters of the distance in the lowest beds of chalk by curving the line to the southward after leaving the shore, but it would be one and a half miles longer.

The submarine tunnel on the Shakespeare Cliff line would be about three miles longer.

On the Fan Hole-Sangatte line we know almost certainly that we shall have a vertical thickness of some 500 feet of chalk to tunnel through, giving about 250 feet above and almost as much below the center line of the tunnel. Along the Folkestone line there cannot be more than 250 feet of chalk, and that thickness is uncertain, as the dip of the chalk and greensand from its outcrop is purely conjectural; so that neither the gradients nor the line of the tunnel can be fixed beforehand, and the making of it will be risky and tentative from beginning to end.

I hope I have shown the danger of trying to feel one's way with borings, and a serpentine tunnel might at any time lead into difficulties.

There is no difficulty of tunneling in beds even of the upper chalk saturated with water and full of open fissures on the land. Why should an engineer be afraid of tunneling in the upper beds of the lower chalk under the sea where open fissures are not so likely to be met with? Open fissures will form under the sea as on head, if an outlet is provided and time given for draining the saturated chalk. The small runs of water I saw in the French works in the lower chalk could not have existed without open fissures extending far enough into the saturated chalk to supply the water flowing from them, and as the pumping goes on underground closed fissures will open out and the discharge of water will increase as larger areas of saturated chalk are exposed on the sides of the fissures.

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* Paper read before the Royal Society of Arts, and published in its *Journal*.

Whatever, therefore, may be urged as to the advantage of trying to follow these lowest beds of the chalk near the outcrop on the Shakespeare Cliff route in order to avoid water, which at the best is an uncertain advantage, would be more than outweighed by some very obvious and certain disadvantages and even positive dangers in attempting to do so.

The arguments set forth nearly fifty years ago for making the Channel tunnel in the beds of chalk hold good to-day. No new facts have come to light. Some shafts have been sunk at Dover through the chalk to the coal measures. In some of these much water was met with, in some little, which is what could have been foretold from our knowledge of the chalk.

From other causes the cost of making and of working the tunnel has been reduced. We have no longer to provide for the removal of the large quantity of carbonic-acid gas which locomotives produce. The traffic can be worked electrically. In addition to this, our knowledge of tunneling by machines through water-bearing strata has been increased by practice in the tunnels made under the Thames and for the tube railways.

Sir John Hawkshaw had satisfied himself as an engineer, not only that the tunnel could be constructed, but as to its utility as regards trade and commerce, and at the inquiry held by the Select Committee of the House of Lords and Commons in 1883 expressed himself to this effect. He was pressed very much by the committee to give an opinion as to whether the construction of the tunnel would be a source of danger to the nation, and while asserting that he had considered the tunnel from an engineering and commercial point of view, he maintained that the question of protection or defence was one for the consideration of the War Office, who had already, as I have stated, appointed some of its officers to visit Dover with the object of specially reporting upon the position of the entrance and the protection that might be considered necessary. Consequently, after the report of the Select Committee that it was not expedient that Parliamentary sanction should be given to a submarine communication between England and France, the whole question was naturally dropped.

All those who took part in the inquiry I have attempted to describe, and in the incidents it led to, excepting myself, have passed away. Lord Stalbridge, the chairman of the first company, who was the first boy I fagged for at Westminster School sixty-three years ago; the directors of the original Channel Tunnel Company, the engineers, my father, Brunlees, Low, and Ed. Easton, whose knowledge of working in water-charged chalk was so great; Day and Topley, the geologists, and my old friend, H. M. Brunel, who did such good work; Bellingham, our untiring secretary; Brunton, whose clever machine would have done the tunneling work; the contractors, Brassey and Wythes; and Crampton, who experimented for us on the transport of chalk in a fluid state. They are all gone; but if a Channel tunnel is ever made their work should not be forgotten, and especially my father's, on whose judgment they all relied.

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Mr. J. Dobson, after reading the paper, said: "There are just a few remarks I should like to make in connection with the great scheme of the proposed Channel tunnel, which is again before the country. As a matter of fact, I was brought up (so far as the early part of my professional career was concerned) in the very atmosphere of the tunnel scheme, having had the privilege of serving the last year of my pupilage—1864 and 1865—with Sir John Hawkshaw, and for twenty-five years as one of his assistant engineers, until I became a partner of the firm. I well remember the preparation of the early sets of plans, each set consisting of five. Indeed, there were naturally so many sets to make that it seemed at the time as if we had to do with nothing but chalk. The cartoon was compiled from information supplied by Mr. Hardwick Day to whom Mr. Hawkshaw refers, and is signed, as are the others, by John Hawkshaw, James Brunlees, and William Low. The plan in the Channel Tunnel Company's publication of December, 1912, is an exact reproduction of this plan, but without the signatures. Now I think we are much indebted to Mr. Hawkshaw for bringing before us the early history of the work done by Sir John with regard to this grand enterprise, which we all considered was, and would be, the great work of his life, for it is not well to forget those who have borne the burden and heat of the day, and especially the one who was the first practical pioneer of this scheme.

"There are just two points in the paper to which I should like generally to refer—construction and protection. First, as to the construction of the tunnel. Mr. Hawkshaw draws attention in his paper to Sir John's evidence before the Joint Committee of the Lords and Commons in 1883, when he stated that he had satisfied himself as an engineer that the tunnel could be constructed. But upon referring to the minutes of evidence, I also find this statement made by him—a statement which should go a long way to help the Channel tunnel forward to-day: 'If it is desirable that the tunnel should be made, I should be willing to risk my reputation if I am asked to undertake it and to make it.' Now it should be remembered that this statement was made in the early days, when tunneling was very different from what it is to-day, and before electrical working was proposed or thought of for the railways. Mr. Fell, the chairman of the House of Commons Committee, to whom we are much indebted for all he has done, and is doing, toward the furtherance of this great scheme, in his valuable paper recently read before this Society, drew attention to the fact that in nothing has greater progress been made in recent years than in tunnel building, and this is perfectly correct. Therefore, if Sir John Hawkshaw, in 1883, made the statement he did, how much more confident, owing to these great changes, would he have been to-day in his ability to carry it out. From the paper it is, I think, clearly shown that one of the great points in Sir John Hawkshaw's mind was that the tunnel, if built, should be in the lower or grey chalk. I am sorry to see that the proposed tunnels do not follow the line laid down by Sir John Hawkshaw, because his line (see map page 19) for the most part would pass through a thickness of some 450 feet of chalk practically in the center of the same, while that laid down by the present advising engineers does not appear to secure the advantage of so great a depth of grey chalk. Second, as to the protection of the tunnel. When the question of protecting the tunnel came up in 1883, we who were then Sir John's assistant engineers, used to discuss very freely how we would get rid of the invaders, and the general feeling was that the best way would be to flood them all out, and it is certainly interesting to find that Sir Francis Fox, in opening the discussion on Mr. Fell's paper, suggests the same method of protection. It is true that placing the entrance under cover of the guns, or flooding the tunnel, one would have considered more than sufficient, but this would have meant wholesale slaughter, such as would result from a submarine attack. Here again we have a proof that as time passes things change, for better or for worse—and certainly in this case for better—for to-day Mr. Fell has clearly shown us in his paper that there will be no need to protect the tunnel either by firing or flooding, because the French, to satisfy our military authorities, have agreed that the sole power-station shall be on the English side. Now, what does this mean? Simply that, by moving a lever the whole of the power for working the traffic can be stopped—temporarily or permanently. Much was said at the Joint Committee in 1883 as to the national element of danger which would arise if the tunnel was constructed; but surely if this is so, only additional precautions are necessary to counteract the danger, as is the case in every improvement where traffic is concerned. To illustrate my meaning, take the London traffic, and let us look back, say, fifteen years. We see the old four-wheel cabs, hansoms, and 'buses. Now, speaking for myself, I was thrown right out once from a hansom, and once the hansom was overturned with me inside. In both instances it was found the men were slightly the worse for drink, and it, unfortunately, was not a rare thing to find drivers in that condition. To-day we go by mechanically-propelled vehicles, which carry us at least twice as fast as the hansoms, and in the midst of traffic which is enormously increased. Can we expect to do so without incurring extra risk? Yes, we do. But why? Because, and no one can fail to observe it who will take the trouble to do so, the men who are driving the mechanically propelled vehicles are a totally different class—quick-sighted and energetic, and men who, as a whole, are first-class drivers, and I have never seen one the worse for drink; while the efficiency of the police in the control of the traffic—always good in the old days—is to-day, with this enormously increased traffic, perfectly wonderful. Therefore it is obvious that any supposed increased national danger, owing to the construction of the Channel tunnel, can be minimized by increased careful supervision, and if, as I have pointed out, by the movement of one handle the whole traffic could be stopped temporarily or permanently, and by the movement of another the tunnel could be entirely closed, should it be considered necessary, then is it to be supposed we cannot depend upon our men doing such a small thing as this? Surely even the thought is absurd, for if such were the case, I think we should deserve to be invaded, but may God grant this may never occur."

Radiation and the Atom

Sir J. J. Thomson's Investigation

PROF. SIR J. J. THOMSON, O.M., president of the Physical Society, described, in the Cavendish Laboratory, to the members who visited Cambridge recently, the latest results of the experiments that he has been making on the production of very soft Röntgen radiation, with a view of investigating the properties of the atom.

The researches of Röntgen and his pupils, he said, had always connected-up light with electrical waves, or waves produced by what he might call mechanical means. There was a slight gap between the well-known red radiation and the shortest electrical wave that could be produced by the ordinary mechanical means. The study of Röntgen radiation had enabled them to prove the existence of two separate rings of electrons in the atom, one inside the other. The one was responsible for what was known as the K kind of radiation, and the other had the L characteristic. The L characteristic was so much softer than the K that if the rate of increase in softness was in anything like the same proportion, the radiation from a third ring would come well within that region of radiation which at present had not been studied. If they commanded a continuous series of radiations they would be able to see how many separate vibrating systems, how many rings of electrons, there were inside the other, and, more than that, they would be able, by the study of that radiation, to gage the number of electrons in each ring. This study, therefore, promised to give them the means of determining the distribution of electrons throughout the atom, and that was mainly the reason why they had lately in that laboratory been trying various methods of exciting that type of Röntgen radiation and studying its properties.

Two methods had been employed. The first was the production of Röntgen radiation by the impact of positively charged atoms. As far as he knew, no radiation due to the impact of positively charged atoms had yet been detected; but by taking advantage of the very remarkable sensitiveness of the Schumann photographic plate, they had been enabled to get unmistakable evidence that as the positive rays impinged against a surface they gave out a type of Röntgen radiation. A Crookes tube was employed for these experiments. His second method, he said, was on more orthodox lines, and in using it they had studied the effects of the impact of cathode rays, the speed of which was very much under their control. For these experiments an ordinary Röntgen-ray tube was employed. The photographic method, he continued, involved a considerable waste of time, and they had lately tried experimenting with a substitute for the photographic plate, and if they succeeded with those experiments they probably would be able to get on much more quickly. But even with the photographic plate they hoped to make a series of experiments which would enable them to find how many rings of electrons there were in an atom.—*The English Mechanic and World of Science.*

Graphite Against Furring

VARIOUS methods have been proposed and tried for preventing the furring of boilers. So far the best success has been obtained with those systems which prevent the deposition of scale right from its inception. In Germany many large firms of engineers, spinning mills, weaving mills, and other users of machinery, have found that graphite is a most efficient means to this end. In proportion to the size of the boiler, from 1 to 2 kilogrammes of graphite are placed in the boiler after it has been well cleaned. In addition to this 15 grammes of graphite must be added for every 100 liters of water evaporated. The process is as follows: The walls of the tubes, owing to the different temperatures prevailing in the boiler, expand in varying degrees and fissures or splits are thus continually produced in the furstone as it forms, and, into these, the graphite penetrates and finally covers the whole wall of the tube so that scale is no longer able to adhere thereto. Of course only highly pulverized, perfectly pure, graphite must be used.

California Led Last Year in Timber Sold from national forests, though Montana had the largest number of sale transactions.

Seventy-Six-Ton Steam Shovel*

Designed for Large Outputs and Heavy Material

We publish herewith illustrations of a 76-ton steam-shovel, of which several examples have recently been constructed by a Lincoln firm of manufacturers. The machine has been designed to deal with large outputs and heavy material, and marks the culmination of an experience extending over thirty-eight years. The same firm also build the crane-navvy, or full-circle type of machine, as well as the limited-swing steam-shovel of the class we now illustrate. Their range of crane-navvies covers weights from 18 to 60 tons, and their range of steam-shovels 20 to 76 tons. The machine we illustrate has been designed for large outputs and heavy material. It is normally fitted with a bucket of 3½ cubic yards capacity, but for exceptionally heavy or light material a smaller or larger bucket would be fitted. A machine of the type shown, excavating very heavy rock used in making Portland cement at a quarry in Aberthaw, and operating on a working face 30 feet deep, is loading 7-ton wagons in from one to one and a half minutes.

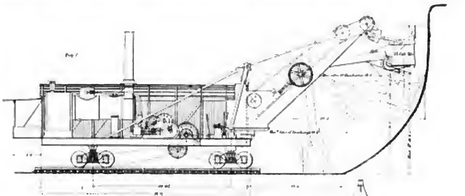
The general lines of the machine are well shown in Figs. 1 to 3. It consists of an under-frame built up of heavy joists, and plates are supported on two four-wheel bogies. The jib and its turntable are mounted at the front end of the under-frame and are balanced by the boiler carried at the other end. Separate hoisting and slewing-engines are mounted in the center. The travelling gear is operated from the hoisting-engine. The jib carries a bucket-arm, the movement of which is controlled by the main chain and by a racking-gear mounted on the jib. A rack formed on the under side of the bucket-arm gears with a pinion, which is gear-driven by a racking-engine mounted on the jib. This gear determines the projection of the bucket-arm from the jib, and hence the depth of the cut taken from the working face. The force required for cutting is supplied by the hoisting-engine, which hauls the bucket upward, the arm in the meantime swinging round the center of the rack spur-wheels. Various possible positions for the bucket and arm are indicated in Fig. 1, which gives the maximum digging height, range of discharge, etc. The bucket is discharged by releasing a door, which forms its bottom, this being controlled by a rope, which is operated by the man who looks after the racking-gear. Views of the machine in operation are given in Figs. 4, 5, and 6.

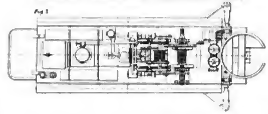
This brief description should be sufficient to make the working of the machine clear in a general way, and we may now proceed to deal with the details of its construction, leaving any further account of its method of operation to the end of the article. We may begin with the hoisting and slewing-engines, which are well shown in Fig. 7, and of which detail drawings are given in Figs. 8 to 10. These engines are to some extent built together, as will be clear from Figs. 8 and 9. The slewing-engine lies between the side-frames of the hoisting-engine, and the slewing-drum and second-motion shaft are mounted on these same side-frames, which carry the crank-shaft bearings of the hoisting-engine. The upper drum, i. e., the left-hand one of the two in Fig. 9, is the slewing-drum, the hoisting-drum being in front and at a lower level. The hoisting-engine has cylinders 10 inches in diameter by 14 inches stroke, and is fitted with link reversing gear. Crank disks are employed to add fly-wheel effect. The slewing-engine has cylinders 7 inches in diameter by 7 inches stroke. It is controlled and reversed by a single lever, which operates a change-over valve. The engine is practically a duplicate of the racking-engine which is illustrated in Figs. 11 and 12, and to which we refer below.

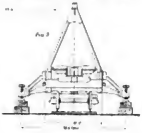
The operation of the hoisting and slewing-engines is under the control of the driver, who stands at the front of the machine close to the hand-levers, which can be seen in Figs. 1 and 2 and in Figs. 5 and 7. As is best shown in Fig. 7, there are three main levers: a smaller lever, a pedal, and a further lever on the far side of the platform, which can be seen to the left in Fig. 7. This far-side lever is for the purpose of operating the traveling-gear clutch. It is not used during the ordinary working of the machine, and is purposely placed well away from the control-levers proper. Of the three main levers, one operates the steam-clutch of the hoisting drum, which we will describe in a moment, another controls the link motion of the hoisting-engine, and the third the change-over valve for the slewing-engine. The smaller lever, to the right in Fig. 7, is for the operation of the throttle-valve for the hoisting-engine, while the pedal is connected to the brake of the hoisting-drum. The driver has a further lever under his control, which is not shown in Fig. 7. It can, however, be seen in Fig. 5. It is pivoted above his head, and operates the throttle-valve of the racking-engine which is carried on the jib.

The steam-clutch is a very interesting feature of the hoisting-engine. It forms an easily operated and powerful gear by which the load can be taken up instantaneously upon the driver pulling over the hand-lever. It can be put into action with the engine running, and no special care is required, as the action is automatic as soon as the lever is pulled over. The clutch will transmit the full power of the engine and lift a test-load of 30 tons. It is well shown in Fig. 7, and is detailed in Figs. 13 to 15. As will be seen from Figs. 8 and 9, the crank-shaft of the engine drives the spur-wheel on the hoisting-drum shaft through a pinion. The spur-wheel is secured to the shaft, but the hoisting-drum is free from it. The hoisting-drum carries a clutch-drum at one end, which is embraced by a wood-lined clutch-strap. The strap is pivoted to the spur-wheel in such a way that when it is tightened on the clutch-drum the whole arrangement drives together. As will be clear from Figs. 13 and 14, the strap is tightened or released by the movement of a toggle which is operated by a bell-crank lever lying at right angles to it. The bell-crank lever is pivoted to the spur-wheel, and the end of its inner arm lies in a slot in the shaft. A steam cylinder is mounted at the end of the shaft and axial with it, as is well shown in Figs. 7 and 14. The cylinder piston-rod is directly connected to a plunger working in a hole in the end of the shaft, the plunger having a slot at its inner end, in which the end of the bell-crank lever-arm fits. It will be clear that the movement in or out of the cylinder piston will move the bell-crank lever, and so expand or release the clutch-strap. The piston is controlled by a simple slide-valve, which admits steam to either end of it, the valve being operated by the hand-lever already mentioned.

At the other end of the hoisting-drum from the steam-clutch there is a brake-drum with a wood-lined band-brake, operated by the foot-pedal already mentioned. This is used to sustain the load while the jib is slewing preparatory to the discharging of the bucket. The main drum itself is grooved for the hoisting-chain, as shown in Fig. 1. It works on long brass bushes. The traveling-gear for the machine is worked through a spur-gearing, situated at the brake end of the hoisting-drum, and shown in Figs. 8 and 9. This gear is thrown into connection with the main shaft by a dog-clutch when it is desired to bring it into use. From the







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* Reproduced from *Engineering*.

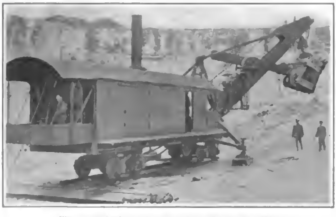


Fig. 1.—Shovel working in a chalk quarry at Hessle.

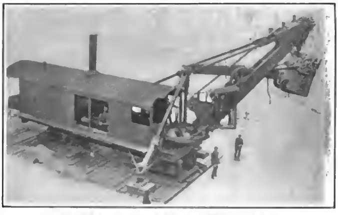


Fig. 5.—Shovel working in a chalk quarry at Hessle.

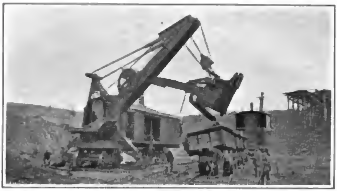


Fig. 6.—Shovel excavating at Hull joint dock.

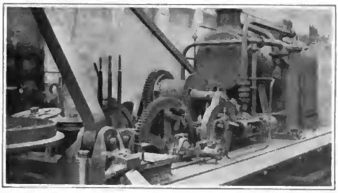
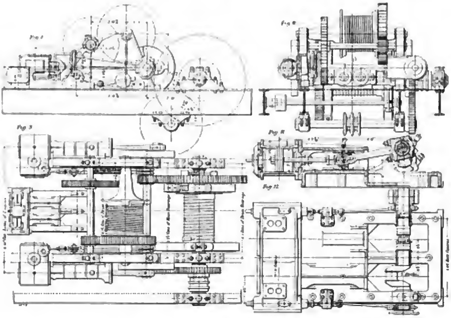


Fig. 7.—View showing hoisting-engine and boiler.

second-motion shaft of this gear, power is transmitted to the traveling-wheels by flat-link chains, as shown in Fig. 1. The chains allow for a certain amount of side swing of the machine. The bogies are of the diamond-frame type, of specially heavy construction, and heavy compression springs are fitted to absorb the stresses due to digging and traveling. The bogies are best shown in Fig. 4.

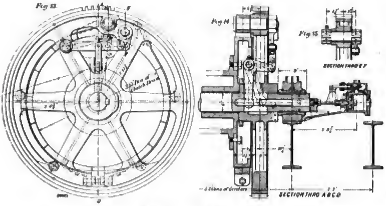
The boiler is of the locomotive type, which possesses many advantages for this class of work, of which not the least important is that steam can be raised quickly. The design allows ample facilities for cleaning, which is an important point, as frequently bad water may have to be used. The working pressure is 125 pounds per square inch, and the hydraulic test pressure 220 pounds per square inch. A special feature in the construction of the boiler is the method adopted for staying the fire-box and the foundation-ring. The pressure on, and weight of, the fire-box are taken from the foundation-ring by a system of radial staying of the boiler-shell. The foundation-ring is made from Z-bar. There is only one weld in the frame, and the corners are bent in an hydraulic press. The combination of the radial roof-stay and the Z foundation-ring gives an elasticity which amply provides for the breathing of the fire-box. Steam for each of the three engines is taken from the steam-dome by a separate pipe. Each pipe is fitted with a stop-valve and regulating valve. To reduce fuel consumption and avoid strains caused by cold-feed, an exhaust-steam feed-water heater is used, the temperature of the feed being raised to nearly 212 deg. Fahr. Two water-tanks are fitted, one on each side of the boiler, which is mounted centrally on the framing, as shown in Fig. 2. This figure shows the tanks, each of which holds 750 gallons. Feed is by a duplex pump. The boiler is fired from a platform at the rear end, as shown in Fig. 4, and the whole of the body of the machine is covered by a housing as a protection against bad weather and flying material when blasting is being carried on.

The jib, as will be seen from several of the illustrations, is mounted on a turntable carried at the front of the machine. The turntable is built up of mild-steel plates and angles, into which a heavy steel casting is fitted to receive the foot of the jib. The whole rotates on a steel pivot casting bolted to the main framework. Slewing is performed by two wire ropes which pass round the rim of the turntable, and are carried through guide-pulleys to the spirally grooved slewing-drum. The guide-pulleys can be seen in Figs. 1, 2, and 7. In addition to the heavy steel casting forming the pivot there is a further casting built into the front part of the machine. This forms the base of the A frame, which carries the tie members supporting the outer end of the jib. The A-frame legs are solid mild-steel forgings of square section. At the bottom they are pivoted to the casting mentioned above, as is clearly shown in Fig. 7. At the top the A-frame members are bolted to another steel casting, on which the tension-stay crosshead rotates. A back stay connects the top of the A frame to the under-frame below the boiler. The casting to which the bottoms of the A-frame members are pivoted carries two brackets bolted to its ends, one of which is well shown in Fig. 7. To these brackets are pivoted the main members of the jack-arms which serve to take the overturning forces which come into play when the jib is swung to one side or the other. The legs are shown in Figs. 2 and 3, and in all the views of the machine in operation. As will be seen, they carry adjusting-screws at their outer ends, which rest upon wood blocks or packings. When the machine has to be moved the screws are slacked back, so that the packings can be removed and reset in the new position. When traveling, the jack-arms are folded against the sides of the under-frame by removing two pins and releasing the connecting-links.



The jib is illustrated in Fig. 16. It consists of two oak members reinforced on all sides with mild-steel plates. This form of construction has been found to be the best to withstand the severe stresses set up by slewing at a high speed with a loaded bucket. Heavy mild-steel plates and angles are riveted to the top of the jib to carry the chain-pulleys and take the ends of the tension-stays. A mild-steel plate is fitted to form a seat for the racking-engine, while a similar plate carries the bracket for the lower chain-pulley. The bolts for the racking-bearings and the engine are taken right through the jib. The racking-gear is operated by a double set of spur-gears driven direct from the engine crank-shaft. The racking-shaft, which carries the spur-wheels and racking-pinion, is of large diameter and is formed with squares for the wheel-seats instead of keys being used. This eliminates possible trouble through loose keys. The racking-engine is illustrated in Figs. 11 and 12. It has cylinders 7 inches in diameter by 7-inch stroke, and, as before stated, is controlled and reversed by a single valve. Reverse is obtained by altering the direction of flow of steam in the engine, the steam-pipe being made the exhaust-pipe, and *vice versa*.

The bucket-arm is shown in Fig. 17. Like the



Figs. 13 to 15.—Steam clutch.

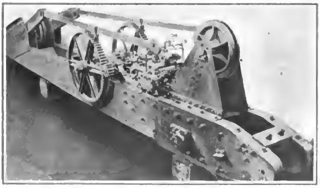


Fig. 16.—Jib looking from bottom end.

jib, it is built up of oak reinforced with steel plates, the rack being a steel casting. The arm is kept in position on the jib by a guide-plate, which is pivoted about the same center as the racking-pinion. The plate can be seen in Fig. 5. The arrangement allows the arm to swing to any necessary angle, as shown in Fig. 1, and allows it to travel endwise, while at the same time keeping the rack always in gear with the pinion. The bucket is built up of mild-steel plates, while the arm, braces, etc., are steel castings. The teeth, which are carried almost the full depth of the bucket, consist of mild-steel shanks with renewable manganese-steel points, and are fitted on a renewable lip-plate. The teeth can be renewed in half an hour. The hinged bottom door of the bucket is provided with a catch, which can be released for discharging by the jib-man pulling a rope, as shown in Fig. 6. The door automatically closes and locks itself after discharging, as the bucket-arm is lowered into a vertical position for the beginning of a new stroke. The jib-man stands on the small platform carried by the jib, and also controls the racking-engine by operating the change-over valve. Steam is conveyed to this engine by an overhead pipe, which has a gland joint to allow for the slewing of the jib. The pipe and joint can be seen in Fig. 1.

Of our three illustrations of the steam-shovel in operation, Figs. 4 and 5 show a machine in a chalk quarry at Hessle, near Hull, and Fig. 6 shows a machine working on the new Hull Joint Dock. We have had an opportunity of inspecting the Hessle installation. The chalk was of quite a hard nature, but the shovel dealt with it easily. The material was dumped by the bucket into trucks brought up alongside, much as in Fig. 6. The arrangement by which the three main motions are dealt with by separate engines appeared to be excellent, and the control of the racking and hoisting worked admirably. The situation of the man on the jib-platform enabled him to see exactly what the bucket was doing, so that he could regulate the extension of the bucket-arm to a nicety, while the easy control of the steam-regulator enabled the driver to humor the bucket up the working face if it came in contact with large boulders or other obstacles. There appeared to be not the slightest difficulty in so controlling the machine that a full bucket was obtained at every stroke. The slewing was very rapid, and the shovel could have delivered material considerably more rapidly than the wagon service could carry it away.

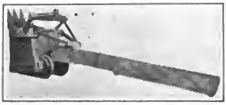


Fig. 17.—Bucket arm and bucket.

Phosphorescent Calcites

M. Lacroix, professor at the Paris Natural History Museum, has presented before the Academy a very interesting paper by M. Pisani, who has observed that certain crystals of carbonate of lime can, under the influence of heat, acquire a remarkable phosphorescence which renders them luminous in the dark. Up till now it was thought that this phosphorescence was due to the presence of small traces of rare bodies. In the majority of calcites there are to be found, indeed, extremely small quantities of yttria; but M. Pisani has operated on absolutely pure crystals of carbonate of lime, and he has observed that when they are heated they become phosphorescent. This curious property of the crystals of carbonate of lime is, then, not due to the presence of rare elements.—*Chemical News.*

The Patent Expert and the Chemical Manufacturer[*]

The Expert's Function in Preventing and in Conducting Patent Litigation

By Bernhard C. Hesse

By "patent expert" I do not mean that professional man who is called in by a litigant only at the critical or crucial stage of a controversy long under way and most usually then in its final stages. On the contrary, I mean that professional man who is not only a highly trained and well equipped chemist, but who has also a natural or an acquired bent of mind which enables him to collect and assimilate the chemical and other facts relevant to the matter in issue, arrange them in logical order, survey them critically, and prepare them for submission to legal analysis and examination by patent counsel, and who makes that particular occupation his vocation in life.

There can be no question that actual patent litigation between inventors or their principals is an unhealthy and an abnormal condition and is thoroughly disadvantageous to the commercial and industrial development of chemical inventions. The energy and ingenuity consumed in litigation could be applied much more profitably to the development of the enterprise itself than to a controversy over where the rights of the one begin and the rights of the other end.

It is perfectly safe to say that the great majority of inventors and their principals are anxious and willing to respect the rights of competitors. They are, however, hampered in the practical expression of this willingness by ambiguity, uncertainty, and error in the statement of supposed rights as expressed in patents. It is to the elimination of these defects that the patent expert must chiefly address his efforts and thus ultimately justify and vindicate his activities and his position in this work-a-day world.

There can be no question that the most economical and profitable employment of a patent expert is at and during the development of a chemical invention itself—not after the patent has been issued and is in litigation. His chief and most useful function is to reduce the likelihood and cost of litigation to a minimum; this he can do only by a careful and patient examination and arrangement of all the relevant facts and by their proper submission to lawyers for final judgment, *before* the application is filed in the Patent Office.

This is merely a specific application of the old adage: "An ounce of prevention is worth a pound of cure." While this may seem to many an obvious and self-evident course of procedure, yet only a minority of the chemical manufacturers and inventors in this country have regarded that course as being, in the long run, the advantageous and proper one for them to follow.

Anyone who has actively participated in strenuous patent litigation and has had his share of responsibilities to sustain, knows the feverish excitement and dissatisfying conditions due to hard work under extreme pressure, the extraordinary and unusual demands made upon the working staff of the litigants from the highest official down, and the consequent unavoidable interference with the regular occupation and operation of staff and works in many, if not all, their divisions. He is also thoroughly convinced that any and all steps taken at the inception of the cause of trouble, namely, the invention and the patents based thereon to prevent such congestion and such high-pressure work must be, in the great majority of cases, far more profitable, economical, and efficient than any attempt at correction or avoidance after the trouble has begun.

It would be idle to expect or to hope that all controversies as to the beginning and ending of rights could be eliminated by such careful preparation of a patent. That the points in issue would be reduced to a minimum is certain, and it is equally certain that the meritorious issues in a case would not be smothered in a mass of minor, technical, or irrelevant disputes, all, or at least the great majority of them, avoidable by care, caution, and patience in the draft of the specification. The smaller the number of such minor points in a patent suit, the shorter the suit and the less expensive to the litigants, while the court and all others concerned are given an opportunity to concentrate attention and effort upon the points that really are meritorious and which alone should count.

It is safe to say that in the average chemical patent suit anywhere from 25 per cent to 50 per cent of the total litigation cost could have been avoided at the outset by proper, complete, and non-ambiguous drafting of the specification and its claims and careful scrutiny thereof after allowance and prior to issue of the patent. A patent conservatively drawn, complete, clear, and full in its disclosure as well as clear in its claims, is far more efficient as a protector against infringement of the invention involved and more certain of favorable adjudication than one not so drawn.

Chemical cases have been litigated in which a misplaced decimal point caused 8 per cent, a superfluous adverb consumed 12 per cent, an incorrect and superfluous theory used up 20 per cent of the total cost of litigation, and finally, had a certain disclosure been just a little bit more explicit, the litigation would not have been started at all. In still other cases, had the relevant art been searched with an open and critical mind prior to patenting, there never would have been any litigation. Further, the number of patents that have been rendered ineffective because of improper statement of invention, insufficient or incomplete disclosure is very great, and most of these defects would, or should, have been avoided in the issued patent had there been suitable technical supervision and criticism such as by a patent expert. It is certainly easier and far less harrowing to examine and criticise an application, even if it be your own work, than to have to sustain an issued and faultily drawn patent when you have no chance for correction or alteration, but must stand or fall by the document, "as is."

The pitfalls are many; there is no really dependable chart; each case must be treated on its own footing. The more careful the search, the more cautious the judgment, and the fuller the knowledge of the relevant facts, the greater the fullness of disclosure, the more circumspect the phraseology and the greater the clarity of expression, the greater are the chances of success in avoiding useless points of attack, in minimizing effort and expense during litigation, and the greater the protective value of the so-resulting patent to a meritorious invention. No amount of bolstering or shoring up *will* or *should* permanently help a non-meritorious invention.

THE PATENT CHEMIST—WHAT HE IS.

The man whose business it is to attend to these matters I have referred to as a patent expert. This appellation is in itself something of a handicap to him in his work. There is no real reason why his expertness, real or assumed, in his special field should ordinarily be emphasized any more than in every-day life a skilled chemist is burdened with the designation of "expert." This man's real business is to be part and parcel of creative organization and machinery, not a man apart. Why not call him "patent chemist"? We have leather chemists, paper chemists, sugar chemists, and the like. The patent chemist is one who specializes in the chemistry of patents, and patents in chemistry. Calling him "patent chemist" makes him on the surface at least more nearly part and parcel of the working staff than does the designation "patent expert"; the former name invites familiarity and co-operation, and suggests utility and work, all of which is only helpful to those concerned, whereas there is a certain amount of aloofness or apartness, a suggestion of extraordinary and formal occasion and surroundings, of so-called "ornament," unconsciously, but none the less surely, associated with any term involving the word "expert."

THE PATENT CHEMIST—WHAT HE DOES.

Now, this patent chemist, as I have called him, what does he do, and how does he set about to accomplish it?

His usefulness begins with the inception of an invention and continues until the last bit of litigation is put out of the way, successfully or otherwise. He begins by getting a close understanding of the invention by careful, exhaustive, and analytical study of the relevant prior art; he determines in his own way the presence of invention, defines the scope and nature of the invention, directs or requires confirmatory or exploratory work in determining and settling its scope; in other words, he formulates and "proves up" the statement of invention. Then he must see to a full and complete disclosure, and finally a proper wording, classification, and subdivision of the claims. His next move is to take his tentative handiwork to patent counsel to see how well or how poorly he has constructed his work; often working together they ascertain and locate weak spots and determine what shall be done to clear up, define, and crystallize the situation.

THE PATENT CHEMIST, THE MANUFACTURER, THE INVENTOR, AND THE LAWYER.

So far, the patent chemist has acted largely as an avenue of communication between the inventor on the one hand who is a chemist, and patent counsel on the other hand, who is generally not a chemist. He must, in many cases, exercise great patience and ingenuity in getting the chemists's story into shape to lend itself to legal treatment, and on the other hand, he must reduce the lawyer's story to such terms that the chemist understands and appreciates the situation.

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More frequently than not, the patent chemist must hold the balance true as against the "fond-parent" enthusiasm, the disdain for real proofs and the airy, generalizing tendencies of the inventor, the aggressiveness of the principal and the pessimism or cynicism of patent counsel, keeping his judgment calm, his reasoning sound, and his facts straight throughout all this, not infrequently, very turbulent and trying period of patent-development.

The amount of labor, effort, study, investigation, re-examination, collecting of new facts or proofs, and restating of positions and viewpoints required of a patent chemist to reconcile these three elements is at times very great and difficult, and always very trying, absorbing, and engrossing.

To establish the usage of a certain expression in chemical publications may seem, at first blush, to be a perfectly simple matter, but before the attempt to establish any particular usage has gone very far one is overwhelmed, more often than not, with a multiplicity of usages, and choice becomes difficult, if not impossible.

The question of what a publication, say forty years old, meant in whole or in part to the man then writing it, to a man reading it thirty or forty years later with all the intervening information at his disposal, is one whose correct answering may or may not interest the inventor or the principal, but patent counsel may know, and the patent chemist must not only get that answer, but he must prove every part of it. The questions of analogy, homology and the like, and their influence upon predication of invention are questions not always easy to answer, but whose answers patent counsel needs, and the patent chemist again must supply and prove in their every part.

Practically all of the great variety of puzzling technical questions which conscientious, capable, and competent patent counsel will propound in the course of developing a patent for a chemical invention resolve themselves into one or the other of the three above given, and the road to the answer is not unusually long, hard, or rocky.

Then comes the question of the accuracy, completeness, fullness, conciseness, and clearness of one's own disclosure, the arguing back and forth over this expression and that expression, this or that sequence of ideas and so forth; the same is repeated on the statement of invention, and finally all has to be gone over again when the claims are taken up.

This kind of work is no occupation for a real chemist, nor an inventor, nor a principal. It is too slow for any of them; their entire mental attitude and habit of thought would have to be changed from an enthusiastic, creative state of mind, based upon an abundance of relevant information to a cold, impersonal, analytic mental attitude based upon information, much of it not wholly relevant, but seemingly wholly foreign to the case; from the joyous and impetuous contemplation of his own creation the inventor would have to drop down to a very chill criticism of his own work as if it were the work of a total stranger. That is for most inventors a practical impossibility, and it is only natural that it should be so.

Essentially the inventor in the usual course of his occupation must take chances—otherwise he would not be an inventor; essentially, those concerned in securing by patent what the inventor has achieved must take no chances, and must be sure that no chances are being taken. It would certainly be extraordinary if both functions were to be successfully united in one and the same individual. Moreover, it as frequently as not takes more labor and effort to get a satisfactory specification together, than it takes to make and operate the invention. Very often, things on paper look very different from the real thing, but it is a most difficult operation to reduce those differences to comprehensible and concise written language. The average inventor would rather follow up the practical realization of his invention, or start something new and fresh, than be obliged to go over and over the same old trail straining his eyes for something he does not care to see, and which does not hold nor grip his interest. His particular work is done; it is up to others now—the patent chemist and the patent counsel. They must dig into the relevant chemistry and the relevant court decisions, write and rewrite the specification and claims until, in their judgment, all foreseeable contingencies are provided for and taken care of.

THE PATENT CHEMIST AND THE PATENT OFFICE.

At last, the specification is filed in the Patent Office, and quite as often as not, the first Office Letter will show the patent chemist that he did not provide for all chemical contingencies, and the patent lawyer that he did not provide for all law contingencies, or in the event they have done both, they evidently did not succeed in saying so in a manner that *could not* and *would not* be misunderstood. Then the work must be taken up anew; explanatory letters must be written, and many times these are not sufficient, and personal interviews are needed to uncover the cause of the misunderstanding. Here again the patent chemist must take up the technical side of the case, which, as a rule, he can present conclusively far better than the patent lawyer, just as the patent lawyer is far better able to present conclusively the law involved. Experience has shown, however, that law points are then far less frequently involved than are technical points.

If now the application, when in allowable shape, is put into interference, it is the patent chemist who must in the last resort decide if the proposed interfering claims are, or are not, such that his case can properly make; then the details of the interference proceeding and the preparation of the technical testimony, direct and cross, for and against, should all pass the patent chemist's scrutiny. The quality and amount of work required of the patent chemist in such proceedings is dependent almost wholly upon the caution and alertness exercised by him during the development of the application.

When finally a patent is issued and negotiations for acquisition of rights thereunder are taken up, it is the patent chemist who must expound the technical aspects of the subject to counsel for the other side, and must again and again defend his work.

THE PATENT CHEMIST AND LITIGATION.

However, the work of the patent chemist so far is a mere prologue to his work when a suit for infringement of patent is under way. Here is where he at times becomes actually the right hand of counsel, and the real test of his ability and preparedness takes place. He must sift and test the evidence of infringement, he must scrutinize and forecast all possible and probable positions of his opponents, must have the entire mass of facts and data at his tongue's end; in fact, he must be a walking and living dictionary, guide book, and cyclopedia not only through the particular art and case involved, but into the most refined and subtle distinctions in any and every branch of chemistry which even remotely touches the subject involved. The patent chemist frequently has the fate of the entire case intrusted to his keeping, and his success depends not only upon how carefully he has prepared his case, but also upon the celerity with which he can produce his proofs and his alertness in anticipating or forecasting the moves, near or remote, of his opponents, and preparing for them betimes. He must be able to do his work quickly and surely not only in the quiet of his laboratory or study, but more often under the strain of proceedings actually in progress and in the presence of his opponents. Not a single phase of the entire case must escape his attention and scrutiny. In one litigated case there was a total of 408 different chemical statements, for each of which all the relevant facts had to be collated from the literature and the relevant testimony on both sides tabulated for use as the case progressed; the subject matter was relatively simple. What would have happed had that subject matter been really complex is wholly a matter of conjecture and fearful to contemplate. Other and more complicated cases have entailed quite as much, if not more, diffuse and widespread labor. Certainly no inventor wants to be pestered with such, for him, dry-as-dust details.

If the crucial test of a patent be its ability to withstand onslaught in the courts, then the crucial test of the utility of a patent chemist is his ability to handle the vast amount of chemical facts involved with alertness, celerity, and accuracy on such occasions. This will be rendered more certain and of a higher degree of efficiency, the greater the familiarity of the patent chemist with the subject-matter, and generally this familiarity is the greater, the longer the patent chemist has been associated with the subject. The same is true of the patent lawyer. Upon this assumption it further follows that the only wise policy is to commit the drafting of the specification and its prosecution in the Patent Office from the very start to that patent chemist and to that patent lawyer to whom the defense of the patent in the courts is to be finally intrusted. Let these men select the ground on which a dispute, if any, is to be conducted while they have an opportunity of so doing; let them shape the course and form of the document over which a struggle is expected, and the results will be far more satisfactory than if those who are finally called upon to defend have no choice in the matter, but must take things as they find them.

It is true that only a very small fraction of the issued patents is ever brought to the supreme test, and it would be a very wasteful policy indeed to expend upon patents of obviously little intrinsic value the same amount of labor that would be called for by a very valuable patent or set of patents. But as to a patent or patents of value there can be no two opinions as to the best general course to pursue; let those who must ultimately do the defending select their own ground while they may.

Many suits for infringement of patents are started or are proposed to be started, many more than actually find their way to trial in the courts in the preparation of the technical matter (both offensive and defensive); in such cases the patent chemist must clear up and maintain clarity in the technical questions involved, because in such informal proceedings success demands completeness, celerity, and alertness to almost the same extent and degree that the more formal court proceedings do. Many a contemplated litigation has not been started because of precisely such proper preparation of material prior to and during negotiations looking to amicable adjustment.

It is not only natural, but inevitable, that the state of known facts changes and shifts and becomes fuller as the inventive idea and the patent pass through the different stages just outlined, and therefore judgment and opinion must frequently be tested and re-examined; these constitute the real cause for keeping the patent chemist in very close touch, in the majority of cases, with the growth and development of the invention, as well as with the business and all other similar conditions surrounding it.

THE PATENT CHEMIST AND THE CHEMICAL FACTORY.

From this sketchy outline of the patent chemist, his field, his mode of operation, and his relation to the manufacturer, it is no doubt clear that he is a man who must look at his chemistry not only with the eye and the mind of a chemist and of a manufacturer, but through the spectacles of a lawyer as well; he must look at patent law with the eyes of a chemist and the mental attitude of a lawyer and translate the law into chemical terms; he must know how to get convincing and correct answers to questions of great variety and scope, many of them seemingly trivial and simple, but at times of the utmost importance. He is neither a producer nor a creator of things; he is perhaps nothing more, in the final analysis, than a catalyst—a catalyst enabling two or more different agencies to operate in harmony and in complete understanding with each other and thus to increase the speed with which the object aimed at is achieved, and with generally beneficial effect upon the quality of the final product. He may also be regarded as a foster-parent to the children of the brains of others, and his function is to aid in their protection while in development. He is perhaps nothing more than an additional insurance against error in making plans for the future, and his value grows with the value of those plans. He is not a lawyer, nor is he a real chemist, but he must be primarily and fundamentally a chemist with a chemist's instinct and a chemist's sympathies; he must have a working knowledge and an appreciation of all business conditions likely to influence the course of development of any and all of the inventions with which he is brought into contact; he is a mixture of chemist, manufacturer and lawyer, and he must have an instinct and judgment for determining the correct time for, and the proper men to whom special questions must be submitted for final treatment. He must be especially alive to his own limitations and to those of others; he must not be unalterably wedded to his own opinions; he must be able, on occasion, to obliterate his own personality and to pocket his pride.

Now this brings me to the question of the status of the patent chemist in the organization or staff of a chemical factory. There can be no question that he must be in the confidence of the concern much more than the routine or works chemist; he must have greater freedom of action, greater radius of activity, and his information should be first-hand wherever and whenever possible. He can make himself useful not only as above outlined, but also by keeping systematic track of what competitors at home and abroad are doing as foreshadowed in the technical press, patent applications and issued patents in all countries, thus anticipating attempts to blanket or forestall his friends, but he may very often also be able to call to the attention of his principals new fields of endeavor and ways and means of entering them, which but for his watchfulness might escape notice. He should be made use of at every new manufacturing or operating step of his principals.

As to his position, should he be definitely inside or outside the organization, the answer is that it depends upon circumstances. In Europe, in some of the chemical branches, the patent chemists are fixed members of the organization, while in others the patent chemists are in business on their own account. Just how each or any organization shall handle that question involves the same questions as does the acquiring of any other commodity or service—by exclusive contract, by provisional contract, or in the open market. Each concern must choose and decide for itself.

To put it in a very few words, the chief function of the patent chemist is to apply Davy Crockett's rule, "Be sure you are right, then go ahead," to chemical inventions—a task not always interesting nor pleasant, but always useful and bubbling over with worth-while work.

The Manufacture of Crucible Steel[*]

Its History and Technology

By George H. Neilson

THE pioneers in crucible melting are said to have been the Chinese, who used the process many centuries ago. But the art in China never progressed beyond the initial stage. The real father of the crucible steel industry was Daniel Huntsman, of Sheffield, Eng., a clock-maker, who found it impossible to get uniform steel from which to make his springs, and he hit on the idea of fusing blister steel in a crucible. This was in the latter part of the eighteenth century, and the melting of crucible steel has changed but little since that time. The details have changed somewhat but the actual process is much the same.

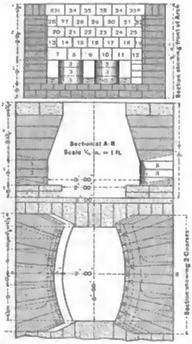

Fig. 1.—Detail of hole in a crucible furnace.

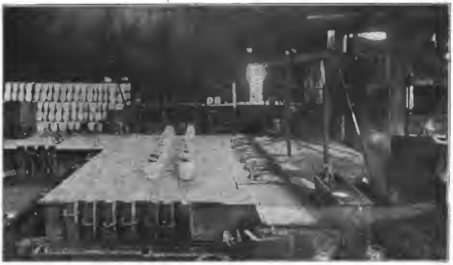

Fig. 2.—A 36-pot furnace.

The material to be melted is loaded in a crucible, covered with a cap to keep out the gases, and placed in a hot hole and left there until melted. The crucibles have changed, the holes also have been changed in shape and size, and the method of heating is not the same, but the process is practically unchanged. Clay crucibles were the first of which we have any definite knowledge. They held about 50 or 75 pounds and lasted but one heat, and very often cracked and went to pieces before the steel was melted. Clay crucibles of the present day are much more durable and are extensively used in Europe, but little in this country. They have one decided advantage over the plumbago, or graphite, crucibles inasmuch as they do not throw off any carbon during the melting process. The plumbago crucible, which is the most generally used in this country, consists of about equal parts of plumbago and clay. The greater part of the plumbago is imported from Ceylon. These crucibles are capable of withstanding a very severe heat, and can be used a number of times, depending greatly on the nature of the mix and also whether the crucibles are replaced in the furnace before they get cold. The usual practice is to get as many heats as possible from the crucible without letting it cool. As soon as the melted steel is poured out, it is re-charged by hand, or by means of a mechanical shaker, and the crucible returned to the melting hole.

Furnace. The modern crucible furnace is of the regenerative type and is heated by gas, generally producer gas, although where natural gas can be obtained it is often used. Natural gas is probably a more costly way to run a furnace, but it has many advantages over producer gas. It is easier to regulate, as the flow is constant, which is not the case with producer gas unless a large holder is used. It is free from the poisonous fumes of the producer gas and is much cleaner. I am not in a position to say whether or not it is harder on the crucibles and furnace than producer gas. The capacity of a furnace is spoken of in pots. That is a 24 pot, 36 pot or 60 pot furnace. That is the number of crucibles the furnace will accommodate at one time. The furnace holes, in which the crucibles are placed, hold 6 crucibles, so a 36-pot furnace is one of 6 holes. The gas enters the holes at the bottom on one side, mixing with the air immediately before entering the melting hole, and passes out at the opposite side and then through checker work to the stack. When the valve is reversed, the direction of the flow of the gas is reversed. This is done every 15 or 20 minutes, and, in this way, the checker work on both sides is kept hot. The gas should not be pulled through the melting hole too rapidly. If it is, it will cut the port holes and also cut the crucibles. The gas should fill the melting hole and show a small flame around the covers. This is a sure indication that the gas is getting around the crucible and not pulling across the bottom. The detail of the hole is shown in Fig. 1, and a modern 36-pot furnace in Fig. 2.

Fig. 3.—A 10-inch bar mill.

Charge or Mix. The basis of good crucible steel is iron, and, consequently, the better the iron the better will be the steel. Therefore, it is vitally necessary that iron low in phosphorus and sulphur be used. As the crucibles generally in use hold from 100 to 125 pounds, the mix or charge is weighed up in lots of that weight and placed in pans, called weigh pans, from which it is transferred to the crucibles. In order to get the exact analysis, the weighing must be carefully done, in many cases to the exact ounce. When the crucible is filled it is covered with a cap. This is done to exclude deleterious gases which otherwise would impregnate the steel. When the material to be melted is weighed up, the amount of carbon given off by the crucible must be taken into consideration. If this is not done, the carbon content of the ingots will run higher than expected. The new pots, as a rule, do not throw off as much carbon as they will the second time used, and after the third heat the amount thrown out will be immaterial.

Melting. The length of time necessary to reduce the mix to a molten state varies, depending on the makeup of the mix itself, and will take anywhere from 2 to 5 hours. When the steel becomes fluid, it is usually good practice to "kill it," or, in other words, drive out the gases which would otherwise result in blow holes in the ingot. This process of "killing" usually takes from 20 minutes to one hour or longer.

Molds. The molds in general use are known as split angle molds. They are made in two pieces, held together by rings and wedges—one ring at the top and one at the bottom. The three essential qualities are long life, smooth finish and tight joints. If the inside finish is not smooth, the ingot will have a rough surface which may result in defects in the finished bar. If the joints are not tight, the hot metal will work through and form a fin on the ingot. This fin will have to be removed, which means added cost. If it is not removed, it will work into the steel and cause complications. The smaller molds have the bottoms cast with the sides. The larger molds, 7-inch and over, have no bottoms as a rule, the molds being set up on removable bottoms. Before the molds are used, the general practice is to smoke them with rosin, or some other heavy, greasy, smoke-making material. This prevents the ingots from sticking, and also makes a smoother surface. The molds should also be warmed before using.

Teeming or Pouring. Teeming is a very important feature and is not merely dumping the hot steel from the crucible into the mold in a haphazard way. In the first place, the stream must be steady; if it is stopped and then started again there will be a weak spot in the ingot. The chilling of the metal first poured, however slight, will result in a non-homogeneous mass and the ingot when hammered will break at the point where the stopping of the stream occurred. The stream should never be allowed to strike the sides of the mold; if it does it will cut the mold and the result will be rough ingots, and in a heat or two put the mold out of commission; also the stream should be started as gently as possible. If it is teemed in without care the metal will splash against the sides of the mold, and cause the lower part of the ingot to be rough. This teeming is not as easy as it looks and it takes considerable practice to make a man an expert. The weight lifted is quite considerable; the crucible and the tongs weigh about 60 pounds and the steel about 100 pounds, a total of 160 pounds. When you remember that this weight has to be lifted and held steady so that the steel will flow from the crucible evenly and at a uniform rate, the difficulty of doing the work properly can be appreciated. It is not altogether a question of strength, it is knack. Some of our strongest furnace men never learned to teem properly. They had the strength but could not master the art. When a ladle is used, of course, the difficulty of teeming is done away with as the steel can be dumped into the ladle as fast as possible and the teeming is then done from the ladle itself. Both methods have their advantages. It is necessary that the molds be set up straight, or, in other words, plumb; if they are not the melter is more than likely to teem against the side, and also a mold out of plumb is apt to have a bad effect on the steel as it chills. Before the steel is poured out of the crucible, the dirt, which has risen to the top, should be removed. This is easily and quickly done by means of a steel rod known as a flux stick. The flux will adhere to it and can be removed without trouble.

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[*] Address of the Retiring Chairman of the Mechanical Section of the Engineers' Society of Western Pennsylvania, published in the February, 1914, Proceedings, page 90.

Pipe. The worst enemy of the crucible steel melter is piping. Piping is caused by the sides of the ingot cooling faster than the center. The molten steel which comes in contact with the sides of the mold cools much faster than the center of the ingot. This cooling effect of the mold is felt for as great a distance, approximately, as the mold is thick. In other words, a mold 2½ inches thick will have a chilling effect on the hot steel for that depth, and the result is that the steel thus affected will separate from the rest and the pipe will form. Of course, this result is greatest at the top of the ingot for the reason that the tendency of the pipe to form lower down is offset by the metal from the upper part of the ingot filling in the space. The pipe usually continues as shown in the left hand section of Fig. 4, but often, especially if the teeming has been done too rapidly, the pipe appears as shown in the right hand section of Fig. 4. This is the most dangerous form of pipe, as it is not easy to detect and remains when the visible pipe has been removed. There is no cure for pipe after it gets into an ingot, as it cannot be welded out or worked out and will result in the splitting of the steel when hardened. The most general mode of treating pipe is to use hot tops. A hot top is a brick made of fire clay with a hole through it, the size of brick and hole depending on the size of the ingot cast. The method of handling hot tops is as follows: When the mold has been almost filled, the hot top is placed on top of the hot steel in the mold and the hole filled with the melted steel. This plug, as we may call it, settles into the pipe as it develops, and also has a tendency to keep the top of the ingot hot, and thus lessen the pipe. When the entire mass has cooled, the hot top is broken off and the top of the ingot appears as shown in the right hand ingot of Fig. 5, the hot top, which has been broken off, lying on top of the ingot. The result of teeming without a hot top is shown in the left hand ingot of Fig. 5. The hot top, however, does not prevent the formation of small cavities below the main portion of the pipe as shown in Fig. 4. It should be remembered that the hot top brick must be heated to as high a temperature as it will stand before being placed in the ingot. If this is not done, the cold brick will chill the steel and destroy the usefulness of the hot top.

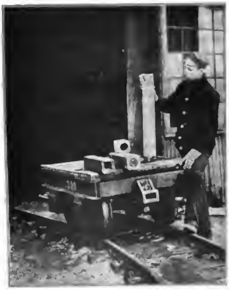
Fig. 5.—Ingots cast without and with hot tops.

To Decrease Pipe. A number of patent molds have been tried but all have been of indifferent success, and the added cost has worked against them. There is no doubt that the present style of mold aids piping, and all of us who are makers of high carbon steel are living in hopes that some day someone will discover a mold that will eliminate it, at least to a great extent. Some of the present molds, those for instance which are tapered with the large end up or those that have hot material packed around the top are merely adaptions of the hot top idea.

Topping. When the ingots are cold, they are removed from the mold and topped, that is, the top is broken off so that a clean fracture is obtained. This is not a laborious job and two trained toppers can top a large number of ingots during a day's work. A trained eye can tell from the fracture the carbon content of the ingot within 0.05 per cent. This is not as difficult as it may seem, and anyone with practice can become very efficient. The manganese, phosphorus, sulphur and silicon cannot be determined this way. Neither can the carbon of high speed steel be determined from the fracture.

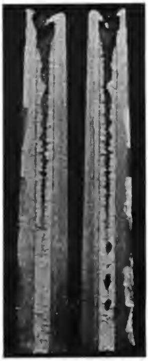
Fig. 4.—Cross-sections of ingots showing piping.

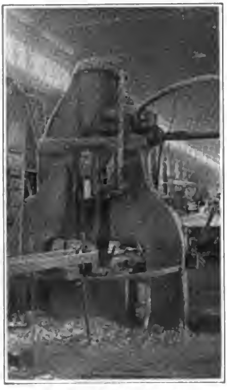
Fig. 6.—A 1,000-pound hammer.

Working. The process of working the steel after it is made is of great importance and the old rule of thumb days are over. The heating of steel was guessed at and many a good piece of steel was ruined by a worker who inherited his trained eye from his grandfather. Luckily for the steel maker, the use of pyrometers is becoming more general every day and guessing at hardening temperatures is rarely done. No steel can be made fool proof, and no overheated steel can be made as good as it was before it was overheated. It can, if not too far gone, be restored partially, but that is all. High speed steel is as near fool proof as any, but even it can be harmed by too much fire. The result of overheating is interesting, and I have here some pieces of steel which show its effect. Later I will be glad to show them to anyone interested.

Rolling. Rolling, like hammering, must be carefully done, if good results are to be expected. The heating should be exact, not guessed at. If the heating is not made to conform to the carbon content of the steel, the results will not be satisfactory. Rolling crucible steel is not a tonnage proposition, it cannot be rushed out if good results are expected. It is unlike open hearth steel, where as a general thing "quantity" is the slogan. To illustrate the difference: In reducing a 3-inch square billet of open hearth to ½-inch round we would have, say 14 passes through a mill driven at high speed, and, at the finish, a bar of approximately 100 feet in length. With crucible steel, if a ½-inch round, we would have 21 passes through a mill driven much slower and a bar about 12 to 14 feet long, but the extra and slower work means a finished bar much closer to size, planished and free from scale. Fig. 3 shows a modern 10-inch bar mill for rolling high carbon crucible steel.

Hammers. Hammers are of two kinds, single leg and double leg. The single leg hammer has one advantage, the absence of one leg allowing the hammerman to work both across and lengthwise on his die, which is at times an advantage. This hammer, however, is more difficult to keep steady than the two leg hammer, as it has a tendency to spring with the blow of the ram and thus work loose on its foundation. The different size hammers and the size of the work usually done on them is as follows: A 500-pound hammer is capable of handling bars ¼-inch up to and including ¾-inch. Fig. 6 shows a 1,000-pound hammer which handles bars from ¾-inch to 1⅝-inch. A 2,000-pound hammer can work bars 1⅝-inch to 3-inch, and a three-ton hammer (see frontispiece), bars from 3 to 6-inch. Of course, smaller or larger sizes than those enumerated can be worked on the various hammers, but the general practice is within the limits given.

The 500-ton steam hydraulic press, shown in Fig. 7, will work high carbon ingots 16-inch square. The press has some advantages over a hammer. It is much easier on the workmen, as it is free from shock and jar, and for this same reason it does not cause deterioration of furnaces and foundations adjacent to it. It works the steel all the way through and gives it a density which a hammer does not. This is probably due to the fact that pressing the steel causes it to flow while the blow of the hammer

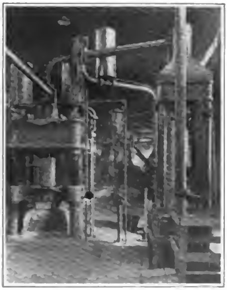
Fig. 7.—A 500-ton steam hydraulic forging press.

is merely local and is not sustained long enough to affect the steel to the center.

Hammering. Hammered steel, that is steel worked into shape under a hammer, must be very carefully handled if the best results are to be obtained. The bar to be hammered must not be overheated, if it is the coarse grain resulting will not respond to the refining influence of the hammer, but it must be soaked, or in other words heated through. The hammering must be done intelligently and the blows of the hammer regulated to correspond to the diminishing heat of the bar. It is also important that the work done should not be done under a hammer too heavy or too light for the work. A heavy hammer will rupture the steel and a hammer too light will necessitate too many blows and continued reheating. The weight of a hammer is, in shop parlance, governed by the weight of the ram, piston rod and piston head. For example, if the hammer is a 6-ton hammer then the rod, ram and head weigh 6 tons. The dies of the hammer are made of cast iron with a chilled surface, ground to a smooth finish. The proper grinding of dies is an art, for if the dies are improperly ground it is impossible to get good results, as the bar will be hard to hold and will jump at each blow of the hammer, the result being that the work will not be true to shape or size. Steel dies are sometimes used but they do not take the smooth surface and polish of the iron dies, and consequently will not planish the steel as well. The proper hammering of steel is the work of an expert. It cannot be learned in a day, and a man to be a good hammerman should have served an apprenticeship under a first-class worker. Although hammermen are paid by the ton the work is not rushed out, and quality not quantity should be the watchword. This does not mean that a man does not do a fair day's work. It is well known what a day's work is on any shape and size, but if the work is to be first-class as to finish and heat treatment, it cannot be rushed, but must be given its proper allowance of time.

Inspection. All crucible steel should be very thoroughly inspected for defects before shipping. It is much better for all concerned to keep your trouble at home, and if there is any doubt as to the soundness of a bar it should be scrapped. It will be cheaper in the end to do this than to take a chance. Inspectors should be given plenty of time and not hurried in their work. All bars should be topped and carefully examined for pipe. Usually pipe is easy to detect, but at times pipe shows in the form of a bright spot, no larger than a pin point, known as a "star." It does not indicate the size of the pipe further in the bar, and must be followed until no trace of pipe can be found. If the surfaces of the finished bars show seams they should be filed out if not too deep. If allowed to remain, they will cause trouble, especially in a cutting tool, as they will cause cracks when the steel is hardened. If the seams are too deep to file out easily, the bar should be scrapped.

Carbon and Alloy Steels. The usefulness of alloy steels was not generally known until a few years ago. Mr. Robert Mushet, who was the pioneer manufacturer of self-hardening or air-hardening steel, made his discovery in 1868. This steel differed from the ordinary or straight carbon steel in that it contained tungsten and that it would harden if heated and then allowed to cool in the air. This Mushet steel had the field to itself until Mr. F. W. Taylor and Mr. Maunsel White, of the Bethlehem Steel Company, discovered high speed steel. This discovery was the result of about 25 years of hard work. About 50,000 experiments were made and recorded at an approximate cost of $200,000. It was unfortunate that these gentlemen did not receive the reward their labors surely entitled them to. Their application for a patent was denied and there was a general rush of steel manufacturers into the high speed market, and to-day there are over 100 brands of high speed steel. The Taylor-White steel was a tungsten steel with the addition of vanadium. These "tungsten-vanadium" high speed steels had the market to themselves until Becker introduced cobalt steel. This steel is a tungsten-vanadium-cobalt steel, which has some valuable properties. Tungsten interested the scientific world some years before Mushet demonstrated its value. We find that in 1783 tungsten was found in the metallic state by D'Elhuyar, who presented a memoir on the subject to the Academy of Science at Toulouse. The Duc de Luynes in 1844 published a memoir on the manufacture of cast and damasked steel wherein he pointed out that tungsten appeared in 8 of 9 analyses given of oriental damasked steel. At the Congress of Miners and Smelters, held in Vienna in 1858, many specimens of tungsten steels were shown. At that time, there were many advocates of the good results of tungsten and also many who could see in it no value.

Do not confuse tool steel with crucible steel. This is a very common error and one which should be avoided. Cast steel is also misleading inasmuch as it often deceives the user. Many of the cheaper grades of tools are made of open hearth steel, which is also a cast steel, so it is seen that tool steel and cast steel do not necessarily mean crucible steel. Another error which is frequently run into is the supposition that the grade of steel depends on its carbon content. This is a mistake and the ordinary grades, I mean by ordinary, straight carbon steel, or in other words non-alloy steel, can be furnished in any reasonable carbon. Another misapprehension under which many users of steel labor is that the grades of steel can be established by analysis. This is, of course, not the case. I have seen many analyses of open hearth steel which were better than the ordinary grades of crucible steel. If the chemical analysis of steel was all that was necessary to establish its worth, the open hearth would have put the crucible out of business long ago.

Edible Fungi*

By W. A. Murrill

The use of mushrooms in this country is as yet very limited, and every season an immense quantity of nutritious, digestible, and palatable food goes to waste in our fields and forests which would be utilized in China and many other parts of the Old World. The reason for this is ignorance and fear; lack of knowledge regarding the edible kinds, and a very definite impression that some of them, or most of them, are dangerous.

All knowledge regarding the edible and poisonous properties of mushrooms is based on experiments, either intentional or unintentional. The only safe rule is to confine oneself to known edible forms until others are proven harmless. If one is a beginner, he is like an explorer in a new country with an abundance of attractive fruit near at hand, which may be good or may be rank poison; he cannot tell without trying it, unless some native, who has learned from his own and others' experience, shares his knowledge with him.

The majority of fleshy fungi are edible. A certain number are bitter, or peppery, or slightly poisonous, or otherwise objectionable, but not deadly. Their digestibility often depends on the way they are prepared and cooked, and on the peculiarities of the individual who eats them. A few are deadly poisonous. Two species, *Venenarius phalloides* and *Venenarius muscarius*, are responsible for most of the deaths from mushroom eating the world over. If these two were thoroughly known and avoided in the vicinity of New York city, there would probably be no fatalities here from mushroom-eating for the next ten years.

My advice to beginners is to confine themselves at first to groups that contain no poisonous species so far as known, or to certain species that cannot be easily confused with harmful ones.

EDIBLE FUNGI FOR BEGINNERS.

Common mushroom, morel, chanterelle, beefsteak, and sulphur-colored polypore.

Shaggy-mane, common inkcap, and glistening inkcap.

All puffballs, provided they are white, tender, and homogeneous within.

All coral-fungi, if they are fresh, crisp, tender, and have no bad odor nor bad taste.

The oyster mushroom and its near relatives. These are large, with white gills and short stems, and grow on dead wood above ground.

After considerable study and experience, more difficult distinctions may be made and other groups taken up.

SOME CRITICAL EDIBLE SPECIES.

Polypores that are sufficiently tender, avoiding certain Boleti and *Fomes Laricis*.

Boleti that have been tested and found edible, avoiding *Suillellus luridus*, *Ceriomyces miniato-olivaceus*, and *Tylopilus felleus* in particular, or all species with red tube-mouths and bitter or peppery taste, and species that turn blue quickly when handled.

Species of *Russula* and *Lactaria* with pleasant odor and flavor, avoiding such species as *L. rufa*, *L. torminosa*, *R. foetens*, and *R. emetica*.

Several species of *Lepiota*, avoiding *L. Morgani*, with green spores, and species of *Venenarius*.

Marasmius oreades must not be confused with *M. urens*, nor with *Inocybe infida*.

Clitocybe, *Tricholoma*, and *Collybia* are usually edible; avoid *Clitocybe illudens*. *Vaginata* too closely resembles *Venenarius*.

Before attempting to use mushrooms at all for food, one should become acquainted with the chief poisonous species, if possible, by consulting any one of several books on mushrooms to be found in the public libraries. The deadly poisonous species are included in the genus *Venenarius*, formerly known as *Amanita*. *Venenarius cothurnatus* is much more common farther south, and *V. solitarius* can hardly be called deadly.

THE CHIEF POISONOUS SPECIES.

Venenarius phalloides, *V. muscarius*, *V. cothurnatus*, and *V. solitarius*.

Clitocybe illudens.

Inocybe infida.

Panus stypticus.

Chlorophyllum Molybdites (*Lepiota Morgani*).

Russula and *Lactaria*, about ten species.

Rosy-spored species, a few.

Several of the phalloids, probably.

Several species not yet tested, doubtless.

Note that no brown-spored, purplish-brown-spored, nor black-spored species are listed above, but not all have been tested.

Nearly two hundred water-color drawings of local edible and poisonous mushrooms have recently been installed in the public museum of the New York Botanical Garden. These are not accompanied by descriptions, nor are the edible species designated, but the student of fungi will have no difficulty in recognizing most of the common local species from these drawings alone.

PREPARING AND COOKING MUSHROOMS.

Reject old specimens or those infected with insects, cut off the stems except in rare cases where they are unusually tender, peel a few kinds that seem to require it, wash quickly in cold water, drain and keep in a cool place until ready to cook. As a rule, mushrooms cannot be kept very long in a fresh condition, and this is particularly true of certain very desirable species. When more are collected than can be used at once, it is best to boil them ten minutes, drain, keep in a cool place, and finish the cooking next day as desired. If allowed to stand in water, the flavor is impaired; also, peeling may remove some of the best flavored parts.

Detailed directions for cooking mushrooms are given in most of the books. The most practical and successful methods resolve themselves into broiling, baking, and stewing. In the first, which I prefer to all other methods, the mushrooms are cooked thoroughly but as quickly as possible on both sides over a hot fire; seasoned with pepper, salt, butter, and perhaps small bits of toasted bacon; and served hot on toast. To bake mushrooms, line the pan with toast, add the specimens, season, pour in half a cup of cream, cover closely, and bake rather slowly for fifteen minutes or more, according to quality. In stewing, the mushrooms are boiled in water until thoroughly cooked, then seasoned, thickened, and served on toast. This last method is often used for the tougher or poorer varieties.

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* Abstract of a lecture delivered at the New York Botanical Garden and published in the *Journal* of that institution.

The Application of Jets for Mixing Purposes

By Oskar Nagel

Jet appliances consist principally of two or more nozzles of increasing diameter and so connected with each other that the jet of gas or liquid passes from a narrow to a wider nozzle, whereby a vacuum is created, and the material that is to be moved is transported by the jet, which acts as motor. Such apparatus is easily handled, has no moving parts, and requires little repair, so that its low efficiency as a motor is not a drawback when used only for intermittent work. The injector, however, occupies an exceptional position, since the heat energy of the steam is recovered by being returned to the boiler.

The low efficiency of jet apparatus as "transporters" is caused by the fact that about 75 per cent of the energy of the jet is consumed in the whirl, which is formed at the transit of the jet from one nozzle to the other. This whirl effects so intimate a mixture of the motor jet with the medium to be moved, that it is a matter of surprise that jet appliances have not been used as "mixers," rather than "transporters."

The chemical industry rather lacks mixing appliances for gases and liquids, and the jet apparatus is well worth consideration for certain operations. One of these is the chamber process of manufacturing sulphuric acid, which requires chambers of very large dimensions in order to mix the gases thoroughly during their passage. Were it possible to introduce the gases as a perfect mixture into the chamber, its dimensions could be much reduced.

While this apparatus has been recommended for moving the gases through the chamber system, its effect as a mixing machine has been entirely overlooked.

In order to use the jet blower as a mixer it must be connected with the system in a different way from what it would be if used for the transportation of gases. It is not enough to lead steam jets through the wall of the chamber, nor to install a steam jet blower without housing into the pipe coming from the Glover. With such an installation only a part of the gases would get incorporated into the whirl, and a partial mixture only would take place. In order to effect a perfect mixture, the whole of the gas must be forced through the nozzles. This is accomplished by tightly connecting the gas pipe of the system, preferably that part which leads from the Glover to the first chamber, with the inlet opening of the steam jet blower.

In order to prevent the gases from entering the chamber at too high a temperature, it is advisable to enlarge the lower part of the casing of the steam jet blower. In the space so gained a tubular cooler is provided (for either air or water), in order to cool the gases to 65 deg. Cent. The gases travel from the Glover through the jet blower to a small chamber, and from here through two reaction towers to the Gay Lussac.

In order to increase the mixing effect of the apparatus as much as possible and to reduce the "motor-effect" of the jet, it is best to have the gas delivered at the inlet opening of the apparatus at atmospheric pressure, so that the function of the jet blower is exclusively to mix the gases, the latter being delivered at the outlet of the apparatus at atmospheric pressure. By this mode of working the efficiency of the jet as a mixing machine reaches a maximum, at which 20 cubic meters of air is drawn through the nozzle by means of 1 kilogramme of steam of 2 atmospheres.

It is clear from these figures that in the chamber process less steam is needed for effecting the mixture of the gases than is required for the reaction leading to the formation of sulphuric acid. The plus of steam necessary for the formation of the acid can either also be sent through the jet apparatus (in which case the apparatus would need to be correspondingly larger), the energy of the plus steam being utilized for the increase of the draught in the chambers, or it may be injected directly into the chamber by means of spray nozzles.

Preliminary experiments show that for a plant in which 3,150 kilogrammes of sulphur are burnt per day, a chamber of a capacity of 850 cubic meters may be sufficient, if after the chamber two reaction towers are provided. The first tower should contain about 20 layers of 20 plates, the second about 20 layers of 12 plates each.

While we are able to utilize the steam jet as a mixer in the chamber process, we can with the same convenience apply the liquid jet in the contact process. In this case sulphuric acid is used as "motor" liquid, while trioxide is the material to be drawn into the whirl. By using a water jet condenser very satisfactory results are obtained in this process of absorption, and also in other processes of similar nature.

An effect in many respects similar to that of jet apparatus is obtained by spray nozzles, since the spray, in forming a hollow cone, creates a vacuum in the direction of its motion. On the other hand, the spray is also a mixing machine and adapted to effect absorption of large volumes of gases with small volumes of liquids. For this purpose the spray nozzle must be inclosed in a suitable cover in order to force every particle of the gas through the hollow cone of the sprayed liquid.—*Journal of the Society of Chemical Industry.*

A Congress of Scientific Kite-flying was held at Boulogne-sur-Mer, France, May 31st and June 1st, 1914, under the auspices of the Ligue Française du Cerf-Volant.

The Rockefeller Institute for Medical Research

A STATEMENT has been given out from the Rockefeller Institute for Medical Research to the effect that in order that further opportunities may be afforded for the more complete investigation of the nature and causes of human disease and methods of its prevention and treatment, Mr. John D. Rockefeller has just donated $2,550,000 to the Rockefeller Institute for Medical Research.

Of the sum just donated a part will be utilized to purchase additional land in New York city so that the Institute will have acquired the entire tract where its buildings are now located, between Sixty-fourth and Sixty-seventh streets on Avenue A, extending through to East River—about four acres. The remainder will be used to erect and equip additional laboratories, buildings, and plant, and to insure the proper maintenance and conduct of the extended work.

This gift of $2,550,000 is in addition to a special fund of $1,000,000 which Mr. Rockefeller has provided in order that the Institute may establish a Department of Animal Pathology. Dr. Theobald Smith, now professor of comparative pathology in Harvard Medical School, is to become director of the new department.

It will be the purpose of this branch of the Institute's work to give special attention to the study of maladies such as hog cholera, foot and mouth disease, and diseases of poultry, which are of such immediate and practical concern to farmers, and the elimination of which is so important. This will be the first enterprise of this kind upon an adequate basis to be established in this country. The results of its work should eventually be of great value in improving the health of cattle and other farm animals.

Mr. Rockefeller's previous gifts to the Institute had amounted to practically $9,000,000, exclusive of real estate in New York city, so that the endowment of the Institute will now approximate $12,500,000.

The Rockefeller Institute will, with the new gift, now become the most amply endowed institution for medical research in the world. In 1902, when the Institute was founded, there was not a single undertaking of the kind in this country. England had the Lister Institute, Germany the Institute for Infectious Diseases, France the Pasteur Institute and Russia the Royal Military Institute at St. Petersburg. Since 1902 a number of other research laboratories have been established in this country, including several in Chicago.

In addition to the laboratories there is connected with the Institute a hospital with every improved facility for the treatment of patients afflicted with diseases at the time under special investigation. For the treatment and study of contagious diseases—a most important phase of the Institute work—there is a separate building with isolated rooms.

The aims of the Rockefeller Institute and the lines along which its future work—upon an even more comprehensive basis—will be conducted, are indicated by some of its practical achievements already accomplished, such as the serum treatment of epidemic meningitis; the discovery of the cause and mode of infection of infantile paralysis, the surgery of blood vessels, through which blood transfusion has become a daily life-saving expedient; the safer method of administering anesthetics by intratracheal insufflation; the skin or tactic reaction and the cultivation of the parasite of rabies.

The scope of the work of the Institute will be indicated by a list of the several special scientific departments which it maintains. It includes pathology, bacteriology, protozoology, biological chemistry, physiology and pharmacology, experimental biology, and animal pathology, besides the special hospital.—*Science.*

Iceplant as a Food

MESEMBRYANTHEMUM CRYSTALLINUM is the scientific name of the singular crystal-covered, white-flowered iceplant, so indispensable in a rockery. *Mesembryanthemum tricolor*, with rose-colored flowers, is the dew-plant. *Mesembryanthemum variegatum* has variegated green and white foliage, with sometimes yellow and sometimes pink flowers.

All kinds are propagated by both seeds and cuttings.

In France the iceplant is cultivated for greens, and cooked like spinach. In England it is valued for garnishing, as we use parsley. The troublesome weed pusley is often used for greens in this country, and is a near relative of the iceplant.

In Africa *Mesembryanthemum edule*, the fig marigold, is highly prized by the Hottentots, who eat the figlike fruits. In Palestine the Arabs make a bread claimed to be more nutritious than wheat, from the seeds of *Mesembryanthemum forskahei*. This plant is of great value for forage, and the seed pods will not open with heat, so the seed gathering is extended through several months. The seed is soaked in water to open the pods, and when stirred, the pods float on top of the water and the seeds sink to the bottom. They are next dried in the sun and ground into flour and baked in cakes sweetened with a molasses made by boiling the seeds of *Juniperus Phoenicea* and straining the liquid.

The United States Department of Agriculture has secured a considerable quantity of the seed, which will surely be of great value as a forage plant, sheep and cattle eating it greedily, the succulent foliage answering for both food and drink. Many lives would have been saved if iceplant of different species had been found growing in our arid southwestern States; and stranded cattlemen and prospectors of the future will have reason to thank Uncle Sam for providing this manna on the desert.

The Safe Operation of Pleasure Cars[*]

Suggestions That No Automobile Owner Can Afford to Ignore

LESS than a quarter of a century ago a person would have been considered visionary and unpractical, to say the least, if he had predicted that a self-propelled vehicle would soon be invented that would travel over the public highways at speeds as high as a mile a minute, and with power sufficient to enable it to climb the steepest hills with ease. To-day a performance of this kind is commonplace, and no special comment is excited by published accounts of automobile races in which speeds of 80, 90, or even 100 miles an hour are attained. When the automobile reached the stage of mechanical perfection that permitted it to travel twenty-five miles or so, without stopping for repairs, it was considered marvelously efficient; but at the present time delays on the road due to mechanical troubles are rare, and the tourist may often continue his journey day after day, without giving any special attention to his machine, beyond providing fuel and supplying the necessary oil and grease for lubrication.

The evolution of the automobile, from the slow, uncomfortable, cumbersome, and mechanically imperfect conveyance of the past, to the swift, dependable, luxurious car of to-day, has been attended by a correspondingly increasing amount of danger, not only to the operator of the car and his passengers, but also to the public at large. The number of accidental deaths in cities has largely increased since the advent of the automobile, and in country towns and on all public highways the danger of being struck by a swiftly moving car, in charge of an inexperienced or careless driver, is always present. Even the careful driver may not entirely escape accidents, because many injuries are direct consequences of carelessness or inattention on the part of pedestrians and drivers of other vehicles. Some of these accidents may be avoided by constant watchfulness on the part of the automobile operator, but in other cases no amount of care will enable him to escape them.

There is no doubt that the blame for many accidents is unjustly laid upon the shoulders of the automobilist, and it is equally true that the neglect of some simple precaution on his part has often led to serious injuries, or even to loss of life. The following suggestions are given in the hope that the risks to users of the public streets and highways may be lessened, and that the operation of automobiles may also be made safer for drivers and passengers.

One of the prime requisites in the safe operation of an automobile is a thorough and instinctive knowledge, on the part of the driver, of the uses of the various levers and pedals that control the movements of the car. The seasoned driver does not stop to think what motions must be made to bring the car to a sudden stop in case of an emergency. When an accident seems imminent he instinctively throws out the clutch and applies the brake, in a mere fraction of the time that would be required if he were obliged to think out each motion in advance. No person should attempt to operate a car in crowded traffic until he has acquired something of this manipulative instinct, and a beginner should not trust himself to drive a car under any circumstances, until he has received adequate instructions from a skilled and experienced operator.

Before leaving the garage the car should be looked over carefully to see that everything about it is in a safe condition. The steering gear and the brakes should receive particular attention in this respect, and loose nuts and other defective parts should be attended to in a thorough manner. The tires should also be examined for weak spots that may blow out while on the road, and tires showing such imperfections should be changed, if necessary, before starting out. Many accidents might be averted by paying proper attention to these points, and by making necessary repairs as soon as the defects are discovered, instead of waiting until a more convenient time.

Although many of the more recently built automobiles are equipped with self-starting devices, the great majority of automobile engines are probably started by means of a crank-handle. The arms, hands, and wrists of the operators are often broken, sprained, or badly bruised by "kick-backs" from these starting handles. Safety handles can be had, which practically eliminate these dangers; but for some reason or other they do not appear to be widely used. Before attempting to crank the engine, the spark should be retarded, to prevent too early ignition. The operator should grasp the crank with his *left* hand, placing his thumb along the length of the handle rather than around it, and *pull upward* on it. When starting a large engine with high compression, it is quite common for a driver to "rock" the handle, to obtain the advantage of the slight momentum given to the flywheel in this way, so that the engine may be more easily turned over the compression stroke; but this is a dangerous practice, and it should be avoided as far as possible. A striking example recently came to our notice, of the utter disregard for safety that is occasionally displayed by drivers in starting their cars. In this case the operator placed the starting handle in a horizontal position, and then *stood* upon it in order to turn the engine over.

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[*] Reproduced from *The Travelers Standard.*

Before attempting to start the engine, care should be taken to see that the clutch has been withdrawn, or that the gear-shift lever is in the neutral position. It is also important to make sure that the brakes are set up tightly if the car is standing on an incline, because if this is neglected the vibration of the engine, after it has been started, may set the car in motion.

When operating a car on the road the driver should listen for unusual sounds about the machine, and if such are noted he should make an immediate investigation to determine the cause. Any marked variation from the usual action of the car also indicates that something is out of order, and prompt measures should be taken to discover the source of the trouble, and to apply the proper remedy.

Attention has been called to the danger of allowing inexperienced persons to operate cars on crowded city streets, where the conditions are entirely different from those that are met with on public highways outside of the city limits, or in public parks. It is necessary, of course, to obey all local traffic regulations, and the driver should faithfully adhere to these regulations, even in the absence of traffic officers. When approaching a stationary street car that may be receiving or discharging passengers, the driver should proceed with extreme caution, and it is safer to bring the automobile to a standstill at a distance of at least eight or ten feet from the street car, and to wait until the passengers have reached a place of safety. Children, and even grown persons, often become confused and suddenly move in directions totally unexpected and unforeseen by the automobile operator, and he should be on his guard against behavior of this kind. The driver, when running the car near the curb, should always be on the watch for persons who may step from the sidewalk into the street without looking about them, or giving indications of their intentions in advance. The most careful person is likely to do this at times, through absent-mindedness or preoccupation, and it is only by exercising constant vigilance that the automobilist can avoid accidents due to this cause.

When a traffic officer holds up a car at a street crossing, or at any other point, it is a good plan to shift the gear lever, *immediately*, to the proper position for starting. Delay in doing this is dangerous, because circumstances may arise that will necessitate a quick "get-away" to avoid an accident. Ordinarily, however, the automobile should be started cautiously after a traffic officer has given the signal to proceed at a street crossing, because some person is usually present who is impatient to cross, and who will try to do so in front of the car. The right of way should always be conceded, without hesitation, to fire-engines and other fire-department apparatus, and if it is practicable to do so, the automobile driver should draw his car up beside the curb until all the apparatus has passed.

In many cities signs are now posted near schools, warning automobilists against fast driving at these points. These warnings and all other similar cautions should be faithfully heeded, and the necessary precautions should be taken to prevent accidents. It is best to avoid the neighborhood of schools altogether, so far as this is practicable.

A suitable warning should be given by a motion of the hand, or in some other manner, before backing the car, turning it around, crossing from one side of the street to the other, turning into a side street, or coming to a stop. If he considers it safe to do so, the driver should glance backward for a moment to see that his signal has been observed by the driver of any vehicle that may be following him, and he should never change his direction until he is satisfied that he has a clear course. Where streets intersect, precedence should be given, in every case, to a car that is following the main avenue of traffic, because any other course may lead to confusion and disaster. At corners where the view is obstructed by buildings, or by high bushes or trees, or in any other way, the speed of the car should be reduced and the horn should be sounded.

Accidents frequently result from the omission of proper precautions when leaving the car unattended temporarily. The switch plug should be removed, the gear-shift lever should be placed in the neutral position, and the brakes should be set up tightly. If the car is standing on an incline it is advisable, in addition, to turn the wheels so that one of them will rest against the curb. If this is done there will be no danger of the car running away in case some mischievous or meddlesome person should release the brakes.

A recent accident, that occurred while one car was towing another one, is instructive and may serve to direct attention to a source of danger that is often overlooked. A man who was waiting to cross the street attempted to pass between the two cars, not noticing the rope that connected them; and before he could step back out of the way he was struck and injured by the car that was being towed. When towing, the driver of the leading car should exercise great caution in every respect. He should drive slowly and carefully, and should make it as evident as possible, to persons who are waiting to cross the street, that another car is attached to the one he is driving.

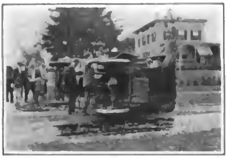


Fig. 1.—The result of skidding.

In addition to the suggestions that have already been given, and that are applicable more especially to the operation of automobiles in the cities and larger towns, there are others that should be mentioned in connection with the operation of cars on the public highways outside of the more thickly populated districts. Excessive speed is one of the chief causes of accidents, and many drivers have a mania for traveling at a high rate, even when there is no definite object in doing so, and when conditions make the practice distinctly hazardous. Except in special emergencies the speed of the car should be regulated to suit the condition of the roads and the density of the traffic. Much depends also upon the skill and experience of the driver, and the automobile operator who is constantly mindful of his own safety and of that of his passengers, will not willingly take chances of any kind. Laws limiting the speed of automobiles have been enacted in many states, and it is safe to say that if the legal speeds were never exceeded the number of accidents would be greatly reduced. Racing on the highways with other automobiles, or with railroad trains or trolley cars, is a dangerous practice, in which no driver should ever indulge.

Safety requires that drivers should always keep on the right-hand side of the road, except when passing other vehicles that are going in the same direction. In such cases the vehicle that is coming up from the rear should always pass to the *left* of the overtaken vehicle. There should be no exceptions to this rule, as any other course leads to confusion and may cause accidents. Some authorities maintain that an exception should be made when passing a trolley car, a furniture van, or any other large, high wagon or load, the size of which prevents the driver of the automobile from seeing ahead on the road; and traffic officers in some cities require automobiles to turn to the *right* in overtaking vehicles of this nature. Unless local traffic regulations require turning to the right, however, we are of the opinion that the rule to turn to the left in overtaking other vehicles should still be followed, even in these cases, although it is then especially important not to turn out too quickly or abruptly. A long sweeping turn should be made, at reduced speed, and preferably at some considerable distance behind the vehicle that is to be passed; and the driver should look sharply ahead in all such cases, so that he will see, at the earliest moment possible, any teams, automobiles, trolley cars, or pedestrians that may be in his course. When about to pass a vehicle from behind, an adequate warning signal should be given, and the speed of the car should be reduced whenever such reduction will diminish the likelihood of accident. A driver should never attempt to exercise his skill by turning in as closely as possible in front of the vehicle that has just been passed, but should allow plenty of room to avoid striking it. Similar rules should be observed when meeting a vehicle coming from the opposite direction, and plenty of room should be allowed in every case. Operators of large cars sometimes "hog the road" (to use an expressive though inelegant phrase), and fail to show proper consideration to the drivers of small cars and of horse-drawn vehicles. Conduct of this kind causes ill-feeling, and in many cases it is also extremely dangerous.

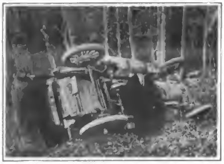


Fig. 2.—The result of breaking a steering knuckle.

When making repairs on the road, care should be taken to move the car as far as possible to one side of the traveled part of the thoroughfare, and no tools, spare tires, nor other material should be left lying in the path of other automobiles. When changing tires or doing other work upon the car while on the road, or when getting out of the car for any purpose, a constant watch should also be kept, to avoid being struck by passing vehicles.

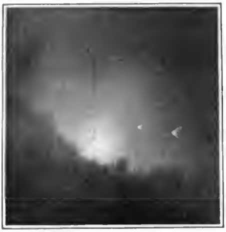
When approaching a frightened horse the speed of the car should be reduced, and if necessary the car should be brought to a standstill, and the engine stopped. Similar care should be exercised when approaching herds of cattle, the car being kept under perfect control so that it can be stopped very quickly. The car should also be kept under full control when descending long or steep grades, and if any doubt exists in the mind of the driver as to the adequacy of his brakes, he should shift his gear lever to low speed, cut off the ignition current, let in his clutch, and thus allow the engine to act as a brake. If it seems likely that the brakes are becoming overheated when descending a long incline, the car should be stopped and the wheels be securely blocked, until the brakes have become cool again. If the brake bands and drums are at a high temperature, they should not be chilled by pouring water upon them, but should be allowed to cool off gradually.

If the engine "dies" (or becomes stalled) while ascending a hill, and the brakes fail to hold the car, the engine may be used as a brake by shifting the gear lever to the reverse position, cutting off the ignition current, and letting in the clutch. This must be done, however, before the car has attained any great speed, because otherwise the gears are likely to be stripped when the clutch is let in, and the danger will be increased. If an emergency of this kind arises the driver should keep as cool as possible, and should remember that the safety of his passengers depends entirely upon his skill, and upon prompt action on his part.

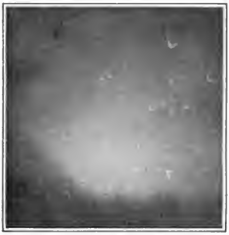
Special care should be taken when driving at night, and in fog, rain, and snow squalls. If the glare of the lights on an approaching car interferes with the view of the road ahead, the car should be slowed down or brought to a complete stop. When approaching unguarded railroad crossings the car should be stopped, if the view is obstructed in either direction, and one of the passengers should be sent ahead to see that all is safe. If the engine should become stalled while crossing a railroad track, the passengers should immediately get out of the car and go to a safe place, meanwhile keeping watch in both directions, in order to warn the driver of approaching trains.

A few general suggestions that are applicable in all cases may be given in closing this article. Intoxicated persons should never be permitted to operate automobiles under any circumstances, even though the intoxication is but slight. Drivers should be on the watch for children who may be "stealing rides" on teams, or who are playing in the streets or on the sidewalks. The operator should at all times keep his eyes on the road ahead; he should not turn around to talk with persons on the rear seat, and he should never remove his hands from the steering wheel while the car is in motion. If the steering apparatus or brakes are known to be defective or out of order, the car should not be operated until repairs have been made. The lights, and particularly the rear light, should be kept brightly burning when driving at night; chains should be used on the wheels during rainy weather and when the roads are freshly oiled or are covered with snow; attention should be given to the proper lubrication of all parts; and the lights of the car should never be left burning while filling the gasoline tanks. Water will not extinguish a gasoline fire, and fires of this kind should therefore be fought with sand, earth, or generous applications of sawdust, or with special chemical fire extinguishers.

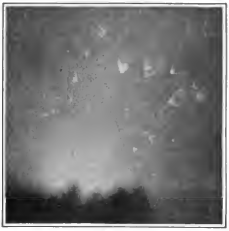
The most important caution that can be given in relation to automobile operation, is to refrain from taking any known and recognized chances, whatsoever. The temptation is great to utilize to the full the enormous power that the automobile engine can exert, and the exhilarating effects of the high speed that may be attained in modern pleasure cars lead many drivers and owners to the most unwise extremes. Safety should be the first consideration in every case, and recklessness and foolhardiness on the part of automobile operators should be discouraged in every possible way.



Taken February 13th, 1901. Z 84. Clear aperture of lens 0.9 inch. Ratio 1:2. Focal length 1.8 inch. Exposure 7 hours 35 minutes — 7 hours 50 minutes = 15 minutes.



Taken February 13th, 1901. Z 85. Clear aperture of lens 0.9 inch. Ratio 1:2. Focal length 1.8 inch. Made by Alvan Clark, Cambridge Port, U. S. A.



Taken March 9th, 1901. Z 114. Clear aperture of lens 0.9 inch. Ratio 1:2. Focal length 1.8 inch. Made by Alvan Clark, Cambridge Port, U. S. A.

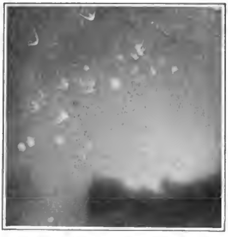
The Zodiacal Light*

Evidence of Cosmic Dust Scattered Through Space

By the Rev. J. T. W. Claridge, M.A., F.R.A.S.

Photographs by A. E. Douglas, Flagstaff, Ariz.

What a remarkable phenomenon is that luminous object in the heavens occasionally seen at this season of the year by the naked eye, and yet incapable of distinct observation by the telescope! Such is the Zodiacal Light. It may be taken for granted that of all the forms which light takes, perhaps this can safely be described as the most delicately beautiful. More milky than the Milky Way, more translucent than the filmy nebulæ, and not altogether unlike the Aurora Borealis, with which it has sometimes been associated, it seems like the concentrated essence of twilight, shooting up into the sky as the sun goes down about the time of the vernal equinox, or preceding the sun as it rises in the autumn. At sunset in March, April, or May, if the atmospheric conditions be favorable, there can be seen a bright tract of the heavens which may be defined as a kind of elongated triangular pyramid or spire resting upon that part of the horizon beneath which the sun has set. Away from all glare of gas light or electric light, it may be discerned without much difficulty. Of course, there must be no moonlight, nor even the brightness of Jupiter or Venus, to interfere with its view. With regard to its position, for all practical purposes we may say that its axis coincides with the plane of the ecliptic or of the sun's equator. This definition, though fairly correct for high latitudes, does not accurately represent it as seen in the tropical regions, where its light is often very conspicuous, and may be seen throughout the year. To an observer in England the cone of light leans somewhat to the left, and lies along the line of the Zodiac. Hence the origin of the name "Zodiacal Light," given by Cassini in 1683. In concord with other celestial objects, it sinks in the west by virtue of the earth's rotation, thereby showing that its existence is external to the earth's atmosphere. Pliny, who flourished in the first century of the Christian era, in his writings seems to allude to this phenomenon under the name of "*trabes lucis*" ("beams of light"), and the renowned Kepler (1571-1630) came to the conclusion that the Zodiacal Light was an atmosphere of the sun. Later on, Cassini, who died in 1712, after several years of observations at Nice, remarked that the northern edge of the light leaned more and more from its ecliptical axis during the months of March and April, when the solar equator was increasing its inclination to the ecliptic, and consequently he concluded that it was a solar appendage. He further described it as having a lenticular shape; that its diameter in June was equal to that of the sun, but much larger in March. In 1731 Mairan spoke of it as a solar reflection, having the form of a flattened spheroid. Humboldt, in his striking work "Cosmos," gives some very interesting notes on the subject, not the least being, in his opinion, that the ancients were unacquainted with it, notwithstanding the clearness of the eastern sky. From his own observations in South Africa, he describes the light as of a "blazing" character at one time, and as an "exquisitely delicate and ethereal object" at another. The remarkable meteoric shower of 1833 caused a goodly number of speculations as to the composition of the light. By many it was thought at the time that the display was due to the earth passing through the material of the light. No less a personage than Biot took up this argument, and suggested that the earth actually passed through the node of this material. About 1852, during Commodore Perry's expedition to Japan, a long series of observations of the light was made by the Rev. George Jones, who was chaplain on the U. S. A. frigate, the "Mississippi." His work, published in 1856, contains a mass of interesting detail, and it appears that he came to the conclusion that the Zodiacal Light was a ring of matter encompassing the earth, and not the sun; since he argued that the changes resulting from the observer's change of position on the earth, as well as the alteration in position caused by the earth's rotation, seemed to him much greater than could be explained if the ring were not relatively near the earth. But surely to this it may be replied that no ring surrounding the earth can in any way satisfactorily explain the phenomenon of the Zodiacal Light. But, assuming it were so, it is quite evident that, at a distance so moderate that a traveler in the tropical regions could recognize the change of position of the light as he passed from the north to the south side of the Equator, it would be invisible from places in high latitudes. In 1864 M. Chacornac observed the light in Paris and Lyons, and said that it was of sufficient power to obliterate stars of the twelfth and thirteenth magnitudes, and covers with a yellowish-red veil the region of the sky on which it is projected. The theory which connects it more immediately with the sun has stood the test of more recent observations. The faint yet exquisite, luster has so far proved amenable to optical tests that the spectrum has revealed its identity with the solar radiance. The light is sunlight, and only differs from the latter in its intensity. It is due to reflection, and, whatever may be the nature of the material which thus reflects the solar light, we may at once dismiss the idea that the Zodiacal Light is a mere extension of the sun's atmosphere. There are dynamical reasons which render this idea untenable; and consequently we are driven to the conclusion that the phenomenon is caused by the presence of a multitude of small bodies, moving in orbits of their own around the sun. In furtherance of this subject two points must be carefully borne in mind. The first is that there are phenomena of the light which indicate some resemblance, remote or otherwise, between its structure and that of comets' tails; so that not only meteoric matter, but also cometic matter, is probably present. The second is that it is highly improbable that the greater portion of the matter forming the light travels in orbits of small eccentricity around the sun. Knowing that the orbits of meteors extend far into space, sometimes beyond the orbits of Uranus and Neptune, we must suppose that the meteoric and cometic matter of its light would travel in paths similarly eccentric, so that it will at times be far beyond the bounds of its visible extent. According to this theory, the light should vary very markedly in appearance from time to time, and this, as a matter of fact, is precisely what has been observed, and remained unexplained until the eccentric nature of meteoric orbits was fully recognized. At the present moment the little bodies composing the light are believed to be something of the nature of Saturn's rings, the light, naturally, feebly reflected from the sun, which renders it so indistinctly visible. This we learn from the researches made by the polariscope and the spectroscope. When we speak of "little bodies" in a cosmical sense, we are naturally compelled to enlarge our ideas with reference to magnitude. Sir John Herschel remarks: "Compared with planets visible in our most powerful telescopes, rocks, and stony masses of great size and weight would be but as the impalpable dust which a sunbeam renders visible as a sheet of light when streaming through a narrow chink into a dark chamber." So it is with the Zodiacal Light. The sun goes down below the horizon, but the rays shoot up into the mass of solid particles which revolves around it, and illuminate their surfaces, the aggregate effect to an observer on the earth being that of a diffused sunbeam, taking the form into which the particles are grouped. Now this word "particle" must also be accepted in a magnified degree. Of course, it may happen that some of the constituent bodies are really small, and certainly none can be very large, otherwise they would not have escaped the careful scrutiny of the powerful, modern apparatus. We may believe, then, that the total mass must be almost nothing as compared to that of the sun. Hence, the central luminary can suffer no perturbation from the vicinity of these revolving bodies, though col-



Taken March 19th, 1901. Z 144. Aperture of lens 0.9 inch. Focal length 1.8 inch. Exposure 7 hours 52 minutes — 8 hours 0 minutes = 8 minutes.

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* Reproduced from Knowledge.

lisions may occur among them, operating in the course of ages to effect a subsidence of at least some portion into the body of the sun, or perhaps into certain of the planets.

An unpractised observer frequently fails to notice the Zodiacal Light, when it is not difficult to perceive it, because the very gradual diminution of its brightness, both upward and laterally, deprives it of any definite outlines. We have the testimony of Schmidt, Jones, and other observers in support of the statement that it gradually fades away toward its edges. Jones especially calls attention to the variations in its brightness from time to time. Others have found it invisible, or at least very faint on some evenings, and it has been thought to be generally brighter in some years than in others. It is recorded that on January 31st, 1853, there were perceptible variations in its brightness relatively to the Milky Way. A distinction could be made between an inner and an outward zodiacal cone, mentioned by Jones as "the stronger and diffuse light." This might have been owing to the varying transparencies of the atmosphere through which the light is seen, or to varying sensitiveness of the observer's eye. With reference to the variation of brightness in different years, the evidence is not very conclusive. If one may venture to draw any inference from the various reports as a whole, it may be said slightly to favor the hypothesis of a variation in its brightness, coincident with the variation in the quantity of solar spots and of auroral displays, but the support at the best is not very strong. Among the few occasions when the light has been brighter than usual may be mentioned the month of March, 1843. That time was rendered remarkable by the sudden appearance of the great comet which caused then such a sensation. It so happened that the Zodiacal Light was noticed as brighter than usual; that Mr. J. Glaisher, writing from the Cambridge Observatory, made the singular mistake of confounding the two objects, saying: "The brilliant train which has for the last few nights attracted so much attention is doubtless only caused by the unusual brightness of the Zodiacal Light." The error was evident to all those observers who had seen the Zodiacal Light towering upward from the horizon, having the Pleiades near its vertex, while the comet came sweeping downward on the left. It is described as a magnificent spectacle not to be forgotten by any who witnessed it. It would seem as if the comet's presence were accompanied by some peculiar translucence of the atmosphere which rendered the Zodiacal Light more conspicuous.

There are also two phenomena which we may briefly notice in connection with this subject. One is the "Gegenschein," or "Counter Glow," and the other is the "Zodiacal Band." The "Gegenschein" is a faint patch of light seen very nearly opposite to the sun's place. Prof. Barnard has studied it for many years, and is of the opinion that it undergoes similar changes to the Zodiacal Light. He describes it generally as a large and elongated patch of light, but not visible in June and December, when it crosses the Milky Way. Not very much is known as to its structure.

The "Zodiacal Band" is simply a prolongation of the light of the "Gegenschein." On some occasions it has been seen to stretch across the sky at midnight from the "Gegenschein," and connecting the evening and morning Zodiacal Lights. It is about thirty to forty degrees in width, and is best seen when it passes between the Pleiades and Hyades. But both the "Gegenschein" and the "Band" are extremely delicate phenomena, and require not only a clear sky, but a clear sight to glimpse them.

It would be presumptuous to say that the phenomenon of the Zodiacal Light has been fully solved. Yet, notwithstanding the apparent faintness of its luminosity, the real amount of light must be considerable. It must not be forgotten that this luminous cone is nearest in that part of the sky which is bathed in the strongest twilight. Could it be seen amid a darkened sky, instead of being almost in the arms of day, its brightness would make it so conspicuous as to attract universal attention, especially as it differs in form from every other celestial object. Unlike the sunbeams, as they shoot upward among the clouds during a gorgeous sunset, the Zodiacal Light is broadest at the horizon, and becomes narrower as it approaches the zenith. In the same way it differs from the fan-like rays of the Aurora Borealis. One thing, among the many, the heavens seem to tell with greater evidence from year to year is that space is not so void and empty as it was once thought to be, and that structures comparatively minute, as well as the immensely large, are widely spread throughout celestial space among the framework of the universe.

On the "Quantum" Theory of Light[*]

Is Energy, Like Matter, Atomic in Structure?

By L. P. Sieg, Ph.D.

WHY are we interested in the subject of radiation? The answer is that radiation of so-called electromagnetic waves is the best connecting link we have between the two things that fill space: matter, and "not matter," or, let us say for the present, ether. If we can learn anything more about these two entities, then we are amply justified in our studies. Let me state then, at the outset, what information we have of these two entities, as connected by radiation. We know that every body in the universe is sending energy to every other body. We call the process radiation. You stand close to a stove and you are aware that something comes to your sense organs, which you call heat. You stand close to a cake of ice and you again detect its presence without the necessity of material contact. Your sophisticated mind tells you that heat is leaving your body more rapidly than it is being received. So, not to be diffuse in this regard, I state that we recognize that matter is radiating energy from itself, and is simultaneously receiving energy from outside. If we examine this radiant energy by suitable apparatus, we find that it seems to have all the properties of a wave, and further with other apparatus we can resolve this wave into component parts, running from waves of infinitesimally short lengths to those of infinite lengths. Not only that, but further, we find that the energy of this radiation is not equally distributed among these waves, but is so distributed that there is one maximum for a certain wave length, and that the energy falls off for wave lengths both shorter and longer than this one. It may be of interest to you to know that in an ordinary room the objects are all radiating, and that the wave length of this radiation that contains the maximum energy is about 1/3,000th of an inch, while on the other hand the sun's radiation finds its maximum at a wave length of about 1/50,000th of an inch, or in the yellow-green portion of the spectrum. The above illustration has anticipated my next point, which is merely that this radiation depends upon temperature and that the higher the temperature, the shorter the wave length at which the maximum occurs. This fact, coupled with the fact that the total energy sent out from a body is proportional to the fourth power of its temperature above absolute zero, constitutes a very essential part of our information of radiation from the standpoint of the hot body.

Now from the standpoint of the ether we have a very satisfactory body of knowledge. Maxwell long ago showed how an ether might be devised, possessing certain electric and magnetic properties, which would carry for us this complicated wave constituting radiation. When this radiation is once well started on its way in the ether, Maxwell's theory handles its progress beautifully. It accounts for a definite speed of propagation; it accounts for interference and diffraction. It accounts, albeit somewhat clumsily, for reflection at various kinds of surfaces, polarization and absorption. However, it does not connect the matter just discussed—temperature and radiant energy—with propagation through the ether. So after all, one can very seriously doubt, in view of what we know of radiation, that we know the connecting link between the heating of a body and the subsequent appearance in space of the radiant energy. There is missing a very important connecting link. This connection is missing, even in view of the modern electrical theories. To sum up this portion of the discussion, we say that in the radiation from material bodies there is associated with every wave length for a given temperature a certain amount of energy, which is a function solely of the wave length and the temperature. The exact type of this function we do not know. It has remained for the Quantum Theory to advance a type of function more nearly agreeing with the facts than any previously known. And, judged solely on this basis, it is a theory well worthy of our serious study.

Before we consider this recent theory, it is important to consider certain functions connecting energy with wave length and temperature, that have resulted from the study of classic thermodynamics and electrodynamics. Remember that any such function must satisfy a condition of equilibrium on the one hand between the kinetic heat energy of the molecules of matter and the electric contents of these molecules, and on the other hand between these electrical contents and what we are pleased to call free radiation in space. It will help greatly throughout this discussion if we imagine a certain space to be enclosed, with walls absolutely impermeable to radiation, and in this space to imagine present together matter in the form, say of an ideal gas, at low pressure and at any given temperature, and its radiation. The walls are to be maintained at the same temperature as the enclosed gas. Further keep in mind that there is supposed to be equilibrium attained in this space, wherein a certain portion of the energy is in the matter, and a certain other portion is in the ether, and so the balance stays, no matter what constant interchange in this energy there may be.

We shall first look at Rayleigh's function which shall be discussed as briefly as possible. The energy possessed by the matter, if sufficient matter is present, is supposed to be divided up into as many portions as there are degrees of freedom, and each of these degrees of freedom possesses its even share of the energy. If there are N molecules present, there are $3N$ degrees of freedom, and so, too, $3N$ separate portions of the energy. Arguing on this basis, and using the laws of Maxwell, and laws from the kinetic theory of gases, Rayleigh arrived at a certain algebraic expression connecting the total energy and temperature. On the basis of the above laws, no one has successfully contradicted Rayleigh's formula. The only successful contradiction has come from experimental facts. The serious objections are these: His formula does not lead to the characteristic maximum of which I spoke at the beginning; the expression for the total energy is only true for long waves at any given temperature, and more seriously still, his hypothesis of equipartition of energy among all the degrees of freedom of motion will necessarily lead to an equilibrium state wherein all the energy in our enclosure is contained in the ether, while the matter therein is at practically absolute zero. This is because, from the evidence of continuous spectra, the ether possesses an infinite number of degrees of freedom.

It was in an attempt to so modify the idea of equipartition that it would not lead to inconsistencies, that led Jeans to announce a modification of Rayleigh's theory. In brief, Jeans admits the infinite number of degrees of freedom of the ether, but says that the ones characterized by extremely rapid vibrations, and those characterized by extremely slow vibrations are so vastly less important that the total energy is, so to speak, temporarily divided among the $3N$ degrees of freedom possessed by the gas molecules, plus the number of degrees in the ether between certain limits. The number of these degrees is by no means infinite. There is then the possibility of a quasi equilibrium between matter and ether, although in the course of a great time, the ether must take practically all the energy.

Yet another function has been developed, this one by Wien, from the standpoint of electrodynamics and the laws of thermodynamics. This function has been successful, in that it has accounted for a certain definite maximum of the energy at a given temperature and wave length. It is unsatisfactory because it fits the experimental facts only at the short wave-length end of the spectrum. It may be added that the exact function connecting these quantities has not been discovered. Wien simply has shown that as soon as the form of the function is known for one temperature, it becomes known for all temperatures. The laws of thermodynamics and of electrodynamics are not competent to give the exact form of the function. We must first form a clear picture of what is going on in the atom.

It remained for Planck to arrive at an expression for this function which seems to fit the facts of experiment with great exactness. It would be a physical impossibility for me to indicate in a short time the steps by which Planck arrived at his formula. His assumptions, however, are: first, that our matter in the enclosure is composed of a great number of vibrating resonators, each of which is the equivalent, if you please, of a wireless telegraph generator, i. e., a Hertz *oscillator*. Each of these has its own period. There is equilibrium between the vibrators and the ether, and the relation between these is obtained by electrodynamics. There is also equilibrium between the molecules and these resonators. It is in this last relation that Planck has made one of his unique assumptions. He has abandoned equi-partition of energy, and has arrived at the distribution of energy among the molecules and resonators through a consideration of probability or chance. It is strange that the same laws that govern legitimate games of chance should stand us in good stead for the solution of problems of radiation! I am sorry that I cannot take up with you, step by step, equation by equation, this remarkable development. Here, as in other portions of this paper, I must content myself with a few of the more interesting of the deductions.

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[*] Abridged report of paper read before the Physics Section of the General Association of Science and Mathematics Teachers.

Those who are familiar with physics will know that there are certain processes in nature that are irreversible. Among them are the natural expansion of a gas, conduction of heat from a hotter to a colder body, and heat lost through friction. There is a law in thermodynamics, the second law, that says of these three—that they are irreversible processes, it is the way Nature acts, and whenever she so acts, she has laid up against her records an increase in something we call entropy. Never has an absolute proof been given for the second law of thermodynamics. We have simply never been able to find an exception. Planck, from the work of Boltzmann, has found a reason for our lack of a proof of this law, for it cannot be proved. It rests on pure chance. In Planck's way of looking at it, the three facts spoken of above: the matter of expansion, conduction, and friction, should be stated in this fashion. It is very safe to say that these three things will always happen in nature, but it is not at all a certainty. In other words, a gas might sometime, of itself, contract; heat might sometime go, of itself, from a colder to a hotter body; and the heat usually wasted in friction might sometime turn itself back to useful work—just a matter of chance, although the chance is vastly in favor of the usual phenomena. Take the first case of the gas. The molecules are moving in all conceivable directions. Why might they not, at some time or other, take it into their heads, so to speak, to move all in one direction? If so, the gas could easily be seen to contract. So then Planck has used Boltzmann's expression for the entropy of our material body in terms of probability. But even this has not been sufficient. He has, lastly, in order to be able to count up the probability, been compelled to assume that the energy which a body expels, *must not flow out uniformly, but must be sent out explosively in integral numbers of a fundamental unit of energy.* He is able to account for uniform absorption of energy, but not for its uniform emission.

I have now, in brief, outlined the general aspects of the subject, and have shown, perhaps not nearly so completely and conclusively as might be desired, the points in which classic electrodynamics and thermodynamics have failed to account for even the most obvious facts of radiation. And lastly, I have outlined, in brief, the essential features of Planck's Quantum Hypothesis. We must now look into this latter theory and review those fields of radiation in which the theory has met not only success, but also failure, for you must know that the complete solution of the problem is by no means at hand. Again let me restate the situation, and enumerate the essential postulates of the theory, for it is on these postulates that we want to focus our attention throughout the remainder of this paper.

The general problem is to find a consistent connection between the energy of radiation in space and the heat energy in matter, this energy to be determined as a function of the wave length and the absolute temperature. Classic electrodynamics and thermodynamics, based as they are on Hamilton's Principle, which necessarily implies the validity of the concept of equi-partition among all the degrees of freedom, and based also upon laws of continuity, have been found to fail in the solution. Starting on quite new grounds and abandoning much of the classic principles of electrodynamics and thermodynamics, Planck has developed a wholly new function, and one, too, that has been eminently successful. The whole foundation of his theory is contained in his statement in the preface to his treatise on Radiation: "Entropy is a countable thing, varying from zero to infinity in its magnitude, and not, as in classic thermodynamics, running from positive to negative infinity." Seen more in detail, his postulates are three in number: first, equilibrium on the basis of electrodynamics between radiation and the oscillators in the atoms of matter; second, the entropy of a body is a function of the probability of its present state; and, lastly, the emission of energy from a body in finite units. I have already illustrated the bearing of probability on entropy. It will perhaps be well to look further into the reason for assuming definite energy units, and some of the consequences of this assumption.

The first, and most important reason for explosive radiation as distinguished from continuous emission of energy, comes from the necessity of being able to handle a finite number of energy units in determining the probability of any certain state of the body. Poincaré has said that since radiation depends upon vibrating matter, and since vibrating matter is discontinuous, then it is not at all illogical to assume that radiation is made up of discontinuities. Sir Oliver Lodge in his presidential address before the British Association warned his hearers that we may some day even come to the belief that time itself is doled out in discontinuous bundles, and that our existence may, in view of some future theory, prove to be no more continuous than the pictures thrown from the kinematograph. But to return to the discussion of these finite bundles of energy.

On both, sound theoretical and experimental grounds, Planck came to the conclusion that these energy units, while finite and definite, were not all of the same size. In fact, the expression for the magnitude of this element of energy is $\epsilon = hn$, when n is the frequency of vibration of the oscillator, and h is a universal constant in radiation, called by Planck the universal *Wirkungsquantum*, or operating quantity. We must later say more of this important constant, h. We learn from this expression that when an oscillator has a high frequency, there is associated with it a large unit of energy, while a low frequency oscillator can emit a much smaller unit of energy. This gives us, without further details, an idea why so little energy is found in the violet end of the spectrum. Simply because in order to radiate here, it requires the absorption of much larger energy units. There are a host of verifications for this assumption in other realms of physics. For example, Nernst and his associates working on the subject of heat capacities of bodies at various temperatures, but particularly at extremely low temperatures, find remarkable agreement between experiment and theory. The reason for the low heat capacities at low temperatures and their increase with temperature, the reason for the law of Dulong and Petit concerning atomic heats, the derivation of many of the classic laws of gas theory—all have been indicators of the success of the Quantum idea, in this domain.

In light we find still more striking verifications. The photo-electric energy can be quite satisfactorily accounted for on the basis of this theory, as also can many of the characteristics of secondary cathode radiation. These two ideas I shall develop a little more fully in a later section of this paper. The apparently simple matter of line spectra has been a problem for the physicist, of no mean proportions. It is easy enough to say offhand that the lines in the spectrum of hydrogen, for example, are due to various electronic frequencies in the atom of hydrogen, when this atom is disturbed, but that is not at all satisfactory. You must know, of course, that an electron vibrating about the positive core of the atom, composes, with this core, a system in equilibrium. In this equilibrium state, with the electron vibrating regularly, no energy can be emitted, because by such an act, the stability of the system must be overturned. That means a change in the vibration frequency and if the emission of radiation is a continuous affair, the frequency change must be a continuous one, and there vanishes the possibility of lines in the spectrum. This past summer, Dr. Bohr, in the July and September numbers of the *Philosophical Magazine*, has proposed an explanation of the production of the hydrogen spectrum on the basis of the Quantum Theory, that is fascinating in the extreme. In brief, Dr. Bohr pictures the single electron in the case of hydrogen vibrating around the core in one of many stable elliptical orbits. No radiation takes place except where one of these stable orbits is changing to another one. Then the radiation is of one frequency, that corresponding to the frequency in the orbit nearer the center, and the energy change in the system is this same, $\epsilon = h$ times the frequency. In this way, all the series of lines at present known in the hydrogen spectrum have been accounted for, and also some other lines have been predicted. Again in the subject of light we may account for fluorescence. By Stokes's law, we are told that the wave length emitted in fluorescent materials is lower in frequency than is the exciting wave. There are, however, some exceptions to this law. On the basis of the Quantum Theory the change in radiation means a change to a lower frequency, and hence to a lower energy. The energy lost has been absorbed, possibly by some slow moving, non-light emitting vibrator. In this latter case, we can say that the frequency is a function of the energy, rather than that the energy is a function of the frequency.

In dealing with absorption, Planck has, according to some physicists, taken a backward step, in that he has found it possible and also quite desirable to consider that the absorption of energy is continuous. One reason for this assumption is that the absorption of a finite amount of energy from an external steady radiation can take place only in a finite time. If the incident energy is too weak, none can be absorbed, and the smaller the intensity of the excited vibration is in comparison to an energy element ϵ, the longer the time for absorption will be. Now with increasing vibration frequency the energy element becomes very large, while we know from experience that the intensity of radiation for this large frequency becomes very small. Here, then, the time for absorption to take place would be far too great to agree with experiment. As a result of this especial hypothesis concerning absorption, it follows that a body which can only emit integral numbers of whole energy elements, and absorb partial elements, can be caught at absolute zero, still in possession of some energy. While at first thought this seems absurd, it is not so strange when we remember that we have defined absolute zero from the standpoint of molecular motion, and have not stated anything definite concerning the energy of the contents of the molecule.

All these experimental verifications from portions of physics outside those portions from, and for which Planck first outlined his theory, have been of material assistance in the spreading of his ideas. For it must be conceded that the Quantum Theory has needed these verifications, for the theory, as regards radiation phenomena, has not always followed the paths of correct logic. Further, the theory puts a great burden on the atom, for there must be present all these oscillators, each with its peculiar period. I have purposely avoided the use of electron, as a synonym for oscillator, just as Planck has done throughout, for the oscillator is at present only a name for something that may have many other peculiar properties, and until we know more of it, we had best use the original word.

Before starting the last section of this paper, I should like to say a few words in connection with the universal *Wirkungsquantum*, or Operating Quantity, h. If we have faith in Planck's theory, we must have the most wholesome respect for this quantity h. It occupies just as fundamental a position in energy as does the elemental charge e in electricity and matter. In fact, at the last meeting of the British Association, Jeans has found a strange and remarkable connection between e and h, two of the most fundamental things and probably the two fundamental things of physics. The relation is hardly definite enough for one to be called a function of the other, but the association of these two, even as tenuous as it seems, has in it possibilities that are fairly thrilling. The one primordial entity, the one universal regulator of the ceaseless ebb and flow of energy in our world of space and matter is being formed for us out of the very mists. Some have attempted to define h in terms of electrodynamics or mechanics, "But such an attempt," says Sommerfeld, "is as useless as a mechanical definition of Maxwell's equation." Energy does not depend upon molecular dimensions, constitution, and the like, but rather the very existence of molecules is a result of the existence of this universal operating quantity, h. Similarly in regard to energy. We have spoken of energy *quanta*, but these while fundamental are not all alike, so that energy itself cannot be conceived as being the fundamental thing in physics. Rather it is this same quantity h, which regulates and controls the manifestation of energy, that is to be looked upon as essentially basic. In his paper before the British Association this summer, Jeans declared for the new ideas, while still holding onto the old, by stating that Maxwell's equations should in their generalized form contain both the quantities e and h, the unit respectively of electric charge and the universal operating quantity. When these two quantities are missing from the equations, then we are dealing with special simplified cases. This is just the reverse of our usual views of this matter. Now, lastly, we have spoken so much of this quantity h, that you may have a desire to know if it has a numerical value expressible in terms of our fundamental units of length, mass and time. Its magnitude has been determined and proves to be the extremely small number, 6.415×10^{-27} g. cm ^{2}/sec., or to make it a little more striking, there is a decimal point followed by twenty-seven zeroes before the first significant figure. In this connection, I cannot refrain from mentioning a new set of fundamental units which Planck has suggested. To take the place of our units of length, mass, time and temperature, he suggests the use of this quantity h, the speed of light, the universal gravitation constant, and the value k in the formula for entropy, where the entropy is a constant, k times the probability of the state of the body. These four units depend upon the universal law of gravitation, the propagation of light in space, and the two laws of thermodynamics. On this system of units the absolute unit of length becomes the very short distance of 3.99×10^{-33} cm; the absolute unit of time and still smaller number, 1.33×10^{-43} sec.; the unit of mass, 5.37×10^{-5} g. and the unit of temperature, 3.60×10^{32} deg. Cent. Had I time, I could give you sufficient reasons for believing these units better than the ones we have. But we must go on to the last section, the one from which the title of this paper was taken.

Surely it does seem strange in this day for physics to ask again the world-old question—What is light?—but they are asking the question to-day with greater insistence than ever before. It did seem five to ten years ago as though we had a well-nigh perfect picture of the mechanism of radiant energy in space. However, the persistence of investigators in the domain of experimental physics has made it necessary, at the very least, for us all to review very carefully our ideas about this matter. The particular development of this subject into the nature of radiation in space, is not a development fathered by Planck, the founder of the Quantum Theory, who has been particularly conservative on this extension of the subject. We owe perhaps more to Einstein, the founder of the relativity theory, than to any other man. It must be stated that Einstein's bold ideas are accepted in their entirety by very few physicists; nevertheless, they are remarkable enough to warrant most serious study. The whole question is, let me repeat: What constitutes light? Is it an electromagnetic wave passing out through the ether of space, or is it something quite different? According to the Quantum Theory of radiation, there is expelled from radiating matter energy in distinct bundles, indivisible for any given frequency. Now in what state does this energy go forth? We are confronted at the outset with a great difficulty in attempting to overthrow the theory of Maxwell, for we have abundant evidence from experiment that this theory does suffice. However, as I said above, there are other experiments according to which Maxwell's theory seems to fail completely. Surely we must not rest content with any theory that cannot explain everything that falls under its domain. On the other hand, we are not justified in abandoning a theory until we can get a more satisfactory substitute. First, a word concerning the much discussed ether

I look on the word ether, as containing two meanings. One is the ether of the philosopher. If the philosopher is unhappy with space that is absolutely empty, then let him fill the space with whatever is necessary to his system of metaphysics. On the other hand, the physicist has an ether which is purely a child of his own intellect. The ether of the physicist is simplicity itself: It is merely a fabricated medium that has just sufficient properties to satisfy Maxwell's equations. If we try to give it any other properties we are getting into the philosopher's domain. If for any good and sufficient reasons we feel constrained to abandon Maxwell's wave equations, just that minute the ether of the physicist ceases to exist. The other man's ether may still be there, but it has no necessary function in the propagation of radiation. Let us follow in a very brief way some of the ideas that have led some physicists to abandon Maxwell's equations, and with these equations the ether of space.

The only thoroughly satisfactory theory of the state of the ether, and in speaking of the ether, I, for the remainder of this paper, shall refer to the physicist's ether, is that of Lorentz. He postulates a motionless ether. This has been tested by the famous Michelson and Morley experiment, with, however, only negative results. Arguing from this alone, and the steps of the argument are long and involved, Einstein comes to the conclusion on the principle of relativity that we come to absurd results unless we abandon the ether entirely. The absurdity comes from the conclusion, assuming Lorentz's ether and the principle of relativity, that we can imagine the ether at rest with respect to either one of two systems of co-ordinates moving through space with different velocities. This, of course, would be absurd. If we must abandon the ether, then the electromagnetic field constituting light is no longer a condition of a hypothetical medium, but represents rather separate images sent out by the source of light. Following this idea yet a little farther, Einstein shows quite conclusively that whenever a body emits radiant energy equal to *L* units, it loses thereby in mass by an amount L/c^2, where *c* is the velocity of light. This further strengthens his feeling that light is not a condition of a medium, but rather that it is something that has as independent an existence as has matter itself. But we need not go to such highly speculative sources. We have some common laboratory experiments that cause us sufficient food for thought. Why, for example, is the photoelectric potential independent of intensity? Let me illustrate in a manner, which, though crude, will perhaps be illuminating. Light a candle and place an insulated sheet of zinc, say one square centimeter in cross-section at a distance of one meter. The zinc attains practically instantly a certain positive charge, due to the liberation of the electrons from its surface. Repeat the experiment with the zinc plate held farther away. Again we get the same potential on the zinc plate, although the intensity of the light on the plate is now much less. If light goes out from the candle in spherical waves, surely the energy falling on a certain area becomes less and less, the farther away the plate is held. Campbell, in his recent book on "Modern Electrical Theory," has calculated that with a source of light of a given intensity a certain photoelectric potential should be acquired, on the basis of the electromagnetic theory only at the expiration of one quarter of an hour, because that time would be necessary, if the plate were perfectly absorbing, to accumulate enough energy to expel the electrons, and thus give the plate the potential that it gets in reality almost instantly. Now, if light is sent out by the candle in *quanta* or bundles, then no matter how far away the plate is, within reason, of course, it will be bombarded with these *quanta*. At any rate it will either show the full potential or none; it will not build up slowly. Again we have X-rays originating from the starting or the stopping of cathode rays. These X-rays fall on matter under proper circumstances, and cause thereby the emission of secondary cathode rays, which latter rays have energy of the same order of magnitude as those of the primary cathode rays. Surely this could not be if the waves constituting the X-rays should spread out uniformly in all directions, for that would lead to a contradiction of the law of conservation of energy. It certainly looks like a bombardment of compact bundles of energy, and not like the uniform spreading out of waves. If we could get a source of light feeble enough in energy it would emit explosively one or more *quanta* at a time in random directions, like the shooting of stars from a Roman candle in the hands of an extremely irresponsible person. For a bright light, multiply this millions of times. This surely is not the picture most of us form of the passing out of radiant energy.

Once more let me ask you to form a picture of the enclosed space containing impermeable walls and radiating matter. It is in connection with this special case that Einstein has exhibited what seems to me his most brilliant reasoning. Grant that the radiant energy is expelled from the matter in *quanta*, and assume for the once that the radiation is continuous. Imagine a small plane, perfectly reflecting surface inside the walls. This surface meets irregular blows from the molecules, supposed to be very sparse, and as a result of these irregular blows it will be moved, just as in the case of the Brownian movement. The radiation pressure on the other hand, is supposed to be perfectly continuous and equal on both sides of the plate, as long as the plate is stationary. However, when the plate moves, it must, in accordance with Doppler's Principle, experience a radiation friction which causes it to be retarded, but this in turn tends to convert the molecular energy into radiation energy. The result will evidently be that all the energy will ultimately become radiation energy, as in the case of Jeans's theory, while the matter will lose its heat energy entirely. The only escape from this is to assume that the radiation is as discontinuous as are the molecular impacts, and the average kinetic energy of vibration of the plate equals one third part of the kinetic energy of a monotomic gas molecule at this temperature. Continuing the argument, Einstein arrives at an expression for the momentum of the plate which consists of two terms: one the standard expression based on electrodynamics, and the other term based on Planck's energy *quantum*. The second term for the case when the temperature is 1,700 degrees and the wave length, that of sodium light, is 65,000,000 times as great as the electrodynamic expression; so much larger, in fact, that the latter can be neglected in comparison with the former. Lastly, quoting from Einstein: "If we should suppose that diffraction and interference phenomena were unknown, but that one knows the average value of the irregular variation in light pressure, where *n* would be a parameter of unknown meaning, determining color, then who would ever build up the wave theory?" However, we can think of the electromagnetic field as collected around singular points, just as in the electron theory, the electrostatic field is built up. When radiation is not sparse, the resultant condition of the field will be the same as on the wave theory, and there is no denying that the wave theory does work admirably for elementary discussion of light problems.

In closing this paper let me quote, this time from Planck: "The Quantum Theory is just as well founded, or even better so, than the old electrodynamics. Only some do not realize the limits of the latter. Years and tens of years are necessary, with much experiment. He who would to-day devote his efforts to the Quantum Theory, must, for a while, be satisfied with the consciousness that the full development of the present labor will not be reached until a later generation."

Heredity Versus Food in Development

It has become a dictum among those most interested in the raising of cattle that "breed rather than feed" determines the quality and output of milk. The food of an animal may be varied within very wide limits without altering the composition of its milk, provided that the ration is sufficient in amount. The only constituent which is known to be altered in milk by changes in the food-supply of the mother is the fat. The composition of butter may be affected somewhat by the food supplied to the cow; but normally little if any influence on the chemical make-up of the milk can be produced by wide variations in the mineral content of the food.

The question as to what extent, if any, the structure and development of the off-spring can be affected by the character of the maternal diet is somewhat analogous to that which concerns the possible alterations in the milk produced by the mother. An idea current among cattle-raisers is that a high mineral content in the ration will cause excessive bone formation in the off-spring.

It has been remarked that "assumptions in nutrition are dangerous." The questions raised in the foregoing discussion cannot well be tested by experiment on human beings; but the effect which a high lime-intake by the mother may have on the skeletal development of the off-spring has been subjected to experiment in the domestic animals. Since grains are deficient in calcium, farm rations made up wholly of them will not supply to growing animals a sufficient amount of this element. For this reason, growing or breeding swine fed entirely on grain, should receive an additional supply of calcium, either as calcium carbonate or calcium phosphate or in leguminous hay. Any drain on the organism with consequent loss of calcium is thus averted. The new Wisconsin experiments, however, have shown that though the nutrition of the mother has a great influence on the off-spring, the size is not modified by the liberal supply of any one element. Although a high calcium ration, containing over five times as much lime as the standard ration, was added to the feed of the mother during the entire period of gestation, no evidence was gained that the skeleton of the fetus was increased in any dimension or in calcium content thereby. If size can be influenced at all by the quantitative relation of the nutrients supplied, it is clear that many factors are involved and not a single mineral element. Size, says *The Journal of the American Medical Association*, is in a very large measure fixed by heredity.

Zirconium Hypophosphite a Photo-Sensitive Salt

By O. Hauser and H. Herzfeld

The hypophosphite is obtained by adding hypophosphorus acid to zirconium nitrate. The amorphous precipitate first formed redissolves in excess of the acid, and is precipitated by excess of alcohol as a colorless, crystalline precipitate, which, when dried over calcium chloride, has the composition $Zr(H_2PO_2)_4$. In direct sunlight the hypophosphite becomes deep violet. Microscopic examination of the colored crystals shows no evidence of decomposition.—*Z. Anorg. Chem.*

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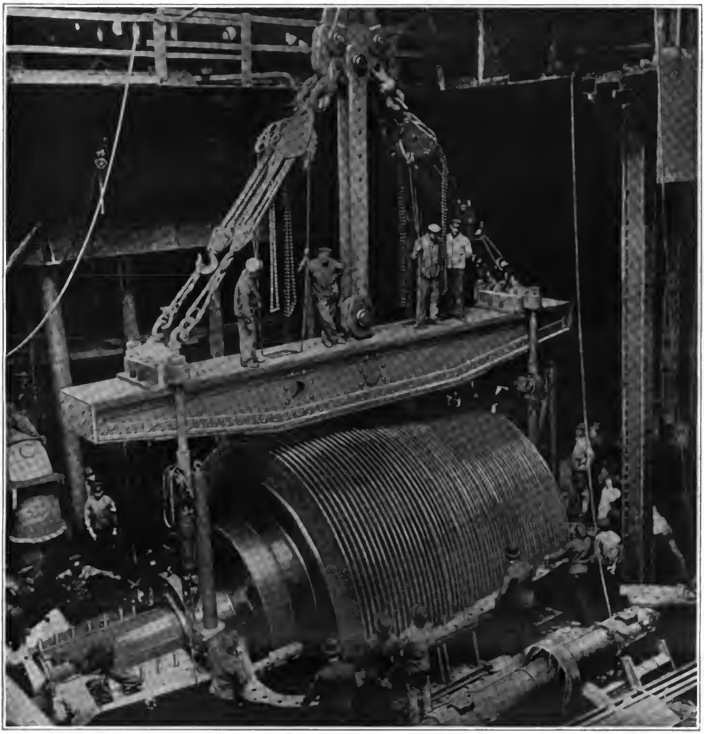

THE STEAMSHIP "VATERLAND'S" ENGINES

The machinery of the steamship "Vaterland," the largest ship in the world, is the most powerful ever installed on shipboard. The liner is propelled by four enormous screws driven by great turbines. In the accompanying illustration one of the forward rotors of the "Vaterland" is shown being lowered into position. The group of workmen surrounding it is completely dwarfed by the rotor, which measures 17½ feet in length and 17 feet in diameter. The "Vaterland" is a sister ship of the famous "Imperator," but surpasses her in every dimension, measuring 950 feet in length, 100 feet in beam, and has 58,000 tons burden. The "Imperator," with a length of 919 feet, a beam of 98 feet, and a tonnage of 52,000, is, in turn, 5,000 tons larger than any other ship afloat. A third ship is now building.

The Chances of Death and the Ministry of Health*

Some Lessons Taught by Vital Statistics

By Frederick L. Hoffman, LL.D.

THE scientific study of death is called thanatology, and, as said by the late Roswell Park, who coined the term, it is a much neglected subject. The best modern treatise on the subject is by Charles S. Minot, published under the title "The Problem of Age, Growth, and Death," in the Science Series of 1908. This is a study of cytomorphosis, or the conception that death is a function of age in its relation to the cellular changes of the body. Just as no one has as yet succeeded in providing an entirely satisfactory definition of life, so also there is no concise description or brief generalization of the terms "death" and "disease." We are not able to give an answer to the question as to how life originated, and it is quite probable that the riddles of life and death will prove continuous with the duration of human existence on the earth.

The conception of death in modern life as a matter of pure chance has no doubt lost much of its earlier significance. The abject terror and the blind acquiescence common to periods of history when epidemic diseases destroyed vast numbers of lives within an incredibly short period of time have given way to an increasing faith and certainty in the prolongation of human existence and the normal attainment of at least the Scriptural period of threescore years and ten. It is quite difficult for the modern mind to visualize effectively the terrible experiences passed through by the people of this country in the last years of the eighteenth century, when yellow fever prevailed as far north as Boston, New York, and Philadelphia, or even in the middle of the nineteenth century, when the same dread disease devastated time and again the larger cities of the lower South. Cholera prevailed to the extent of an alarming epidemic in the city of New York in 1849, and as late as 1905 yellow fever paralyzed the commerce of the South and brought sorrow and grief to the homes of many, from the throne of an archbishop to the hovel of the poor. It would serve no purpose to review on this occasion the sanitary history of the nation or to comment on the frightful waste of human life incident to the epidemics which in the past have devastated this land, hindered its material progress, and brought sorrow and affliction to the homes of helpless millions. Nor would it serve much of a purpose to recall the history of the Black Death of the fourteenth century, which, in all probability, was the most deadly pestilence in the history of mankind. Rather than, in the words of Hecker, the historian of the Black Death, "That Omnipotence, which has called the world with all its living creatures into one animated being, especially reveals Himself in the desolation of great pestilences," is it true to-day that such lamentations and destructive occurrences reveal human ignorance and human indifference, in contrast to realized intelligence and sanitary control. Rather than it being true, again in the words of Hecker, that "Nature is not satisfied with the ordinary alterations of life and death," and that pestilence and plague are revolutions "performed in vast cycles, which the spirit of man, limited, as it is, to a narrow circle of perception, is unable to explore," is the modern and incontrovertible fact that these recurrences, so characteristic of the past history of mankind, can be and are made impossible by a more rational mode of life, considered individually, and in the aggregate subject to intelligent acquiescence in the established truth of sanitary science and sanitary control.

We are no longer seriously concerned with the possible risk of nation-wide epidemics, which are effectively guarded against by a national health service protecting the people against the introduction of plague and pestilence from abroad. Modern preventive medicine concerns itself chiefly with the spread of less destructive transmissible diseases, which still in the aggregate, however, cause a lamentable and largely needless loss of human life. The hygiene of transmissible diseases, their causation, modes of dissemination, and methods of prevention, constitutes a branch of science than which none has yielded results of greater benefit to mankind. Either the causation of such diseases or the mode of their spread from one person to another is now reasonably well understood, and the factors of transmission are controlled to a degree which falls little short of the miraculous. Most of the so-called preventable diseases are diminishing in frequency in civilized countries, chiefly smallpox, typhoid fever, tuberculosis, diphtheria, measles, scarlet fever, whooping cough, malarial fever, etc. Some of these diseases are controlled by vaccination or protective inoculation, as best illustrated in the marvelous results of typhoid fever prophylaxis in the United States Army, by means of which the rate of frequency occurrence has been brought practically to a negligible quantity. Many of these diseases, however, are so widely diffused, and they are so complex in their relation to the human environment and the habits and customs of the human individual, that many years will pass before the death rate will be strictly normal, and one, on being born, will have a fair chance of attaining the maximum duration of life. But the future outlook for life extension is most encouraging, and there can be no question of doubt but that during the next generation a still further material reduction in the general death rate will be achieved.

THE HUMAN CONTROL AND THE DEATH RATE.

The discovery of a great truth serves no real purpose unless the new knowledge is realized in conduct and used in the solution of the problems of society. The realization of the ideal in health administration requires the intelligent, sympathetic, and effective co-operation of all the various interests affected. The burden of responsibility for a high death rate falls, not on the medical profession, but largely upon the public itself, since the problems of sanitary control are largely and fundamentally a matter of Government supervision and concern. The responsibility for life waste is one of inefficient citizenship, on the one hand, and of inefficient leadership and direction, on the other. The duty of direction and control is individual as well as social, and concerns the ministry of the spirit as much as it does the ministry of the body. But the truth has come like a startling revelation to intelligent mankind, that pestilence, and even the common diseases of human life, are largely because of gross neglect, gross indifference, filth, ignorance, and unwarrantable delay in heeding the earliest symptoms of maladjustment in the human economy or the need of repair in the human machine. Problems of life and health are, therefore, matters of most serious concern to the clergy as well as to the physician, to the teacher as well as to the sanitary officer, and, in fact, in no relation of life is the Biblical doctrine that we are all our brother's keeper more beautifully illustrated than in the chances of death and the ministry of health. Rigid conformity to the truth of the causation of tuberculosis, of the spread of diphtheria by personal infection, of the contraction of smallpox by neglect of vaccination, of deaths from yellow fever because of contempt for the stegomyia mosquito, all prove the infinite possibilities of realizing life's larger purposes by the intelligent prevention of its needless waste. Instruction of mothers in the hygiene of infancy will effectively aid in solving the question as to whether the child will live and grow in strength of body and mind, just as rigid conformity to established principles of safety will protect the lives of passengers on land and sea. It is largely a question, first, of knowledge, then, of understanding, and, finally, of unswerving fidelity to the principles of truth as applicable to human conduct for the purposes of human betterment.

THE INCREASE IN THE DURATION OF LIFE.

The present annual death rate of the United States is only 13.9 per 1,000, against a rate of 19.8 in 1880. The saving in years of life in consequence of a declining death rate is so enormous for a vast country like ours that the true meaning of statistical calculations can hardly be made intelligible to the average mind. Sooner or later everyone must die, but the question is one of how long, on the average, each life can be made to last, when a gulf greater than the Atlantic or the Pacific separates the people who in one section live to an average age of 45, and in another to 60. Life tables illustrate with scientific precision natural law as applied to the tenure of man's existence on earth, but what is called the law of mortality is rather a symbolic expression of the law which governs all collective phenomena in the order of logical sequence, without which human existence, and in fact all existence, would be chaos. A study of mortality problems reveals more accurately than many another branch of science the marvels of life in the aggregate as conditioned by the more or less perfect co-ordination of the units, whether merely physically considered, or also in the broader sense of the psychological, moral, and spiritual. The duration of life is determined by an almost infinite number of variants, and even the wisest fail in the attempt to comprehend the whole. The diseases which afflict mankind are numerous, but most of the waste of life is due to a comparatively small number of causes, chiefly, in our own country, tuberculosis of the lungs, accounting for 9.4 per cent of the whole; organic diseases of the heart, accounting for 10.3 per cent; acute nephritis and Bright's disease, accounting for 7.4 per cent; pneumonia, accounting for 6.1 per cent; and cancer, accounting for 5.6 per cent. These six causes alone are responsible for 38.8 per cent of the entire mortality. Other diseases, now largely under control, but intrinsically as serious a menace to community life as any of those mentioned, are typhoid fever, smallpox, measles, scarlet fever, whooping cough, diphtheria, etc. The typhoid death rate, which is typical of sanitary progress or neglect, has declined in American cities from an average of 51 per 100,000 of population during the decade ending with 1892 to 25, or just about one half, during the decade ending with 1912; but our typhoid fever rate is still excessive, and no cause of death perhaps illustrates better the lamentable amount of still existing municipal neglect. Tuberculosis, the foe of mankind for ages, has, during the last generation, been brought within the range of human control, with a fair prospect that within a measurable period of time its ravages will be reduced still more than has been the case in the recent past. The tuberculosis death rate of American cities during the decade ending with 1882 was 318 per 100,000 of population, but the rate during the last decade was only 182. Within more recent years the mortality from smallpox has been reduced from an average of 3.4 during the five years ending with 1905 to a rate of only 0.3, or about one tenth of the earlier rate, during the year 1912. The mortality from the dread diseases of infancy, diphtheria and croup, has been reduced from an average of 29.6 during the five years ending with 1905 to 18.2 during the year 1912. We have no deaths from Asiatic cholera, nor from plague, except at quarantine stations subject to Federal control; either they are isolated or their introduction into this country is practically made impossible by means of a national health administration which challenges the admiration of the world. Yellow fever is no longer the foe of Southern States, and we have had practically no deaths from the disease since 1905. Of leprosy we have a few cases annually, but excepting the well-known leper settlements in Louisiana, there is slight danger to the country of a recrudescence of this perhaps most awful affliction of mankind.

NEW PROBLEMS OF PUBLIC HEALTH.

But with the passing or control of the diseases which have become common knowledge, new ailments and afflictions cause new problems of serious importance, because the conditions of spread are either entirely unknown or but imperfectly understood. Influenza is one of these diseases, which, within recent years, appeared for the first time as a national scourge in 1891, causing, directly or indirectly, an enormous loss of life, and the disease has since prevailed to a more or less extent, either as an immediate cause of death by itself, or as a cause or condition complicating other diseases. Pellagra may be mentioned in this connection as one of the new diseases in this country, the nature and treatment of which are as yet rather doubtful, but the combined efforts of the Federal and State governments, aside from the aroused interest of the medical profession, are at work to determine the methods of control. The word "control," perhaps better than the word "prevention," gives expression to the human effort in the struggle of mankind against disease and early death. No affliction of mankind to-day demands more serious consideration as a world menace than cancer, which has been increasing in practically every civilized country, and in the United States approximately at the rate of 25 per cent during the last decade. Cancer, or malignant disease, is one of the most mysterious afflictions, and it is doubtful whether it will ever be traced to a single cause; it is more likely that it has its origin in a combination of causes and conditioning circumstances largely beyond the penetrating intelligence aided by the most powerful instruments of research. The present solution of the cancer problem is largely one of early diagnosis and the earliest possible surgical treatment, just as in fire-fighting the problem of conflagration prevention is one of efficient apparatus, almost instantaneous notification and prompt response to established needs.

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MURDER AND SELF-MURDER.

The problems of life, disease, and death are endless. The duty of applied intelligence in dealing with questions of preventable life loss and preventable disease is now so obvious on the part of every citizen, and most of all on the part of the leaders of community life in matters material, moral, intellectual, or spiritual, that it seems hardly necessary to refer to the profoundly sorrowful phase of human existence which leads to murder or self-murder, to insanity and degeneracy, or the deliberate impairment, by wrongful conduct, of the physical and mental faculties, with resulting pathological consequences and early death, or decrepit old age. The suicide rate of American cities has increased from an average of not quite 12 per 100,000 of population during the decade ending with 1892 to almost 20 during the decade ending with 1912. More persons die from murder and self-murder in this country every year than from either typhoid fever or diphtheria and croup. The annual loss of life on account of suicide in the United States may be conservatively placed at 15,000, and the average age of these unfortunates is approximately twenty years less than that in deaths from cancer. The subject of suicide has at all times attracted the attention of moralists and of spiritual leaders, but considering the awfulness of the crime of self-murder against God and man, it is a reflection upon our intelligence, our morality, and our conceptions of religious duty that so little should be heard in protest against this, perhaps the most sad and sorrowful phase of human life. The defense of suicide among the Stoics never gained ground among civilized peoples, but there has grown up a toleration and indifference, than which there is hardly anything more deplorable in our present-day period of what we are pleased to speak of as civilization. It has very beautifully been observed in this connection by a writer on self-murder, over two hundred years ago, that, "Whatever the end of human life is, what disputes soever there may be concerning it; it is not the destroying it; since nothing can have being given to it only in order to be not being." There is no more fitting subject for religious discourse than the sanctity of human life, the inviolability of the human person, the duty of facing life's problems with courage, and the ministry of suffering and sorrow as a means toward a more perfect spiritual attainment. There is nothing more deplorable in America than the contempt for life, as made evident by the waste of 15,000 lives through self-murder, and, in addition thereto, more than 6,000 lives ended each year by the murderous actions of others. The phenomena of murder and self-murder emphasize the practical value of a thorough understanding on the part at least of all those who are the responsible leaders in morality and religion of the elementary principles of law in the civil sense of the term, of the disorders of conduct biologically considered, of unsoundness of mind, and the border-land of insanity.

MORAL SIGNIFICANCE OF LIFE EXTENSION.

In other words, the conservation of human life and health, or, as said by Prof. Irving Fisher, the problem of life extension, is not only of economic, but also of great moral significance. The perfection of human character is, partly at least, conditioned by the maximum attainable duration of life, and old age is as essential to human development, moral and spiritual, as is the secular and religious education of youth.

ECONOMIC ASPECTS OF DISEASE.

Prolonged sickness, considered from this point of view, is frequently the cause of human failure, and premature death often terminates needlessly a most promising life. Sickness from preventable diseases is largely the result of social or individual indifference and neglect, but throughout the civilized world the importance of an effective sanitary administration is being recognized, and the principles of sanitary science are being locally applied, with increasing evidence of beneficial results.

REQUIRED CO-OPERATION FOR SOCIAL CONTROL.

The co-operation of the church has for some years been successfully enlisted in the nation-wide effort in behalf of the ministry of health. It has become the custom on the part of the churches to set aside at least one or two Sundays a year for emphasizing the importance of some great public health question, particularly, on the one hand, the need of adequate support for hospitals and other institutions of aid and relief, and, on the other, the urgency of financial and personal co-operation in the fight against tuberculosis. It would not seem to be going too far, therefore, to suggest that this principle of active co-operation should be extended and made to include a more frequent, though perhaps but incidental, discourse on other lamentable phases of human life, particularly, as previously said, the sorrowful and wholly irreligious indifference to the sanctity of human life, as evidenced in the increasing tendency toward murder and self-murder.

PROBLEMS OF MOTHERHOOD AND INFANT MORTALITY.

This view can be carried further and made also to apply to the unborn generations, or the sanctity of marriage as an institution primarily established for the preservation of the family and the continuity of the species. It can no longer be questioned that a vast amount of wrongful conduct underlies the persistent and considerable decline in the birth rate, and it can also not be questioned that a considerable portion of this decline is but life destruction, or murder under another name. Ignorance, however, is the cause of far more waste of child life than deliberate crime, and the still enormous mortality of infants forcibly suggests the necessity for radical changes in the education of young men and women preparatory to marriage and parenthood. Out of every 1,000 persons born, approximately 125 die during the first year of life, largely because of the gross and inexcusable ignorance of mothers whose training in the essentials of motherhood was unhappily neglected. But much of this loss of life is the result of sanitary inefficiency, of a polluted milk supply, on the one hand, and not infrequently of medical incompetence, on the other.

THE MINISTRY OF THE VISITING NURSE.

One of the most efficient aids in the campaign against infant mortality is the visiting nurse, assisting the young mother in the proper care of the child, and providing the required skilful assistance at a period than which there is none other so trying in a woman's life. The visiting-nurse movement is entitled to the most hearty moral and financial support, for the results of an efficient public nursing service benefit the children as well as the aged, and those suffering from slight ailments as well as those suffering from serious afflictions.

PROBLEMS OF CHILD CARE.

No subject appeals more powerfully to the sympathies of mankind of every degree than the physical sufferings of little children born with permanent defects in body or mind, and for all the years of their existence more or less a burden to society. No institution serves a more humane purpose than the orthopedic hospital, where the afflictions of the congenitally deformed, by means of skilful surgery, are reduced to a minimum of physical suffering and physical incompetence; where, in fact, the lame are frequently made to walk, just as in the corresponding institutions for the blind, the deaf, and the dumb, the defects of Nature are partly made good by the skill of man. The institutional phase of modern life is one of increasing importance, for the limitations of the home frequently preclude adequate treatment and care under the best possible conditions. The natural reluctance of parents to part with their children or of families to submit to the seclusion of a much beloved member in an institution for the treatment or cure of some mental or physical defect requires the strongest moral and spiritual support from those who are in the best position to give advice and lend a hand. In all such cases a reasonably thorough understanding of the fundamental facts of human life, the chances of death, the rate of disease frequency, the possibilities of cure, all combine to further the higher purposes of society, and bring about gradually, in however small a degree, the much required improvement in the conditions under which we live.

ALCOHOLISM AND HABIT-FORMING DRUGS.

Perhaps no problem of modern life is more serious in its moral and economic significance than alcoholism and the use of habit-forming drugs. If there is any one lesson taught by modern research into the biological laws which govern age, growth, and death, it is that the human organism cannot be abused or misused without the risk of most serious consequences and the practical certainty of physical impairment and premature death. The evidence is entirely conclusive that over-indulgence in alcoholic drinks is a fruitful cause of disease and moral depravity, while habit-forming drugs, including the misuse of tobacco, often and needlessly change a hopeful career into a hopeless human wreck. The most salutary influence is exercised by those who, by their own example, emphasize the value of right living; but this conclusion applies not only to moderation in the use of intoxicating drink, and much of what goes with it, but also to personal abuse or lack of restraint of every other kind, especially the pernicious habit of overeating, than which there is probably no more fruitful cause of bodily misery and premature physical decrepitude. It has been conclusively shown that those who are overweight live shorter lives and are more liable to diseases—possibly including one of the worst of human afflictions, that is, cancer—than do those who live abstemious lives, are careful in their diet and exercise restraint. The latter not only live longer, but, in the sum total of their years, enjoy a larger share of wellbeing than those who live contrarily to the obvious laws which govern the duration of the span of life allotted to us on earth.

THE FUNCTIONS OF OLD AGE.

Every agency or effort making for health improvement necessarily makes for a prolongation of life. Such prolongation of life is of variable value, according to the age period affected, and while humanely most obvious in infancy and early youth, it is economically most useful during the productive period of life, and spiritually in the later years, when the approach of natural death makes contemplation upon the problems of immortality, and possibly bodily survival after death, an imperative duty, the discharge of which can no longer be relegated to a future which, with certainty, we know is not to be. The utilization of old age, whether economic, social, or spiritual, is one of the most neglected phases of modern life. The neglect has its origin in the fact that in past generations relatively so small a proportion born attained to real old age that, as a practical question, the matter received only academic consideration. With the lowering of the death rate and the increasing average duration and the necessarily larger proportion of persons living into the third generation, this problem of old age and its proper utilization is, from many points of view, one of the most important of the time. The question need not be discussed here further, but it is sufficient to have pointed out its practical importance to the Church as well as to the State.

THE PROBLEM RESTATED.

The present population of the United States is not far from 100,000,000. The number of persons of both sexes, ages 70 and over, in 1910 was 2,270,021. According to the latest English life tables, out of every million born 277,351, or 27.7 per cent, may normally expect to reach the age of threescore and ten. In the United States the annual number of births is about 2,500,000, and the annual number of deaths is about 1,350,000. Of those who died during 1912, approximately 236,500, or 17.6 per cent, had lived less than one year, and 329,400, or 24.4 per cent, had lived less than five years.

The principal causes of death, in the order of their numerical importance and the approximate annual mortality therefrom are as follows: first, tuberculosis, which affects every period of life and causes in the aggregate about 154,000 deaths; second, heart diseases, also affecting every period of life, but chiefly ages over 40, causing a mortality of about 150,000; third, nervous diseases, which account for about 138,000 deaths; fourth, pneumonia (all forms), about 132,000; fifth, intestinal diseases, about 123,000; and, sixth, genito-urinary diseases, about 111,000. Following these six, in the order of importance, are accidents, causing about 182,000 deaths; and tumors, malignant and benign, about 75,000. These eight groups of causes combined account for about 72 per cent of the aggregate mortality of the United States, which, as previously stated, is approximately 1,350,000 per annum. Other important causes are typhoid fever, the mortality from which is about 20,000 per annum; suicides, numbering approximately 16,000; deaths from parturition, about 15,000; and homicides, of which there are from six to seven thousand.

This may be considered the normal mortality of a civilized country not subject to exceptional or uncontrollable mortality conditions, such, for illustration, as continue to affect a great country like India, even at the present time. The death rate of the registration area of the United States during 1912 was only 13.9 per 1,000, against a death rate of 32 for British India. Of the 7,500,000 deaths, in round numbers, during the year 1911, 354,000 were caused by cholera, 58,000 by smallpox, 733,000 by plague, and 4,200,000 by fevers. Most of these causes are no longer an affliction of modern civilized countries, and they are fortunately brought slowly under control in the Indian Empire, where the death rate has gradually been reduced from extraordinary proportions to a rate not much above the normal for the large cities of this country fifty years ago. The best illustration of India's marvelous sanitary progress is to be found in the reduction of the death rate of the European army during recent years. Military discipline and conformity to sanitary rules and regulations, no doubt, largely account for this reduction, which has been of immeasurable benefit, not only to the European, but also to the native population.

The Stackhouse Antarctic Expedition now expects to sail from England August 1st, 1914, in Capt. Scott's old ship, the "Discovery." The start will probably be made from London Bridge, so as to enable the public to witness the departure and give the explorers a hearty send-off. Besides the officers and crew of the ship, numbering 25, there will be about five scientific men attached to the expedition. Lieut. A. E. Harbord, R. N., will be in command of the "Discovery." The scientific staff is to include two noblemen, Lord Congleton, who goes as surveyor, and the master of Sempill. All the officers and scientists will give their services.

The Preservation of Wood—I*

A Synopsis of the Principal Processes in Use To-day

By A. J. Wallis-Tayler

INTRODUCTION.

THE value of wood preservation is now thoroughly recognized, and its importance in the industrial world is rapidly increasing. The advancing cost of lumber has brought home to the consumer the fact that the only possible offset to this enhanced cost is the use of preservative methods to prevent, or rather to retard, decay; and thus not only to lengthen the life of the wood in all its forms, but also to widen the field by bringing into use a number of less valuable species of timber.

In the United States, where, a comparatively few years ago, the supply of timber seemed all but inexhaustible, the amount of lumber now available hardly meets the ever-increasing demand in a satisfactory manner. This is due to careless lumbering, to failure to replant denuded areas, and to the enormous waste caused by forest fires. These remarks are also more or less applicable to other timber countries.

Once divested of life, vegetable substances, in conjunction with animal substances, are liable to decay. Some kinds of wood are more apt to deteriorate rapidly than others, but all woods, under certain conditions, become deprived of the fibrous textures, and thus lose their properties.

Wood consists essentially of vessels and cells, the only solid parts being the coats which form them. In these vessels is the sap, the circulation of which through the tree is the source of its existence. On the death of the tree, however, the sap in the wood is liable to cause vegetable decomposition through the process of fermentation. The fact that putrefactive fermentation, and the subsequent decomposition of vegetable matter, are due to albumen, was discovered by Kyan, the inventor of the "kyanizing" process of preserving wood.

The most common causes of decay are the presence of sap and being subjected to alternating conditions of wetness and dryness, or to a combination of moisture, heat, and absence of ventilation.

Two kinds of decay are distinguished—"wet rot" and "dry or sap rot." The former, which may occur while the tree is standing, takes place where the gases evolved, principally carbonic acid and hydrogen, can escape the tissues of the wood, the sappy portions especially becoming decomposed. The latter, which takes place only in dead wood, occurs in confined places, where the gases evolved, finding it impossible to escape, enter into new combinations and produce fungi, which derive their nourishment from, and thus destroy, the wood. The following illustrations, reproduced from Allis-Chalmers Bulletin No. 1439, July, 1909, show in Fig. 1 a wood-destroying fungus (Lentinus Lepidus) on a red fir sleeper in South Dakota, and in Fig. 2 the growth of destructive fungus on an untreated white oak sleeper.

By felling the timber at the proper season, and at the most suitable age, the tendency to decay can be somewhat reduced. For destruction due to the ravages of insects the only remedy is treatment with some preventive agent. Figs. 3 and 4 show two untreated oak piles destroyed by the teredo navalis, the latter a portion of a pile after only two years' service.

The lower forms of animal and vegetable life, that is to say bacteria, fungi, or spores, assisted by heat, air, and moisture, enter the wood cells and destroy the wood tissue, and as these destructive elements are always present and ready to attack organic matter, it becomes necessary both to destroy them and to render the wood impervious to them, by the injection of some antiseptic or poison in liquid form.

The processes for the preservation of timber from decay, and from destruction through the boring of insects, may be classified under three headings. Drying artificially and hermetical protection from contact with the atmosphere by coating the surface with paint; the elimination of the sap of the wood by dilution or vaporization; the impregnation of the wood with some antiseptic chemical substance which will form an insoluble compound with the organic matters in the sap.

The first and second of the above methods are only valuable where the timber is comparatively thin, is so placed as to be readily accessible, and is not in contact with the ground. The third is the most important, and it is proposed to deal chiefly with processes coming under this head.

EARLY HISTORY OF THE ART OF WOOD PRESERVATION.

The art of wood preservation is probably one of very great antiquity, and is believed to have been practised by the ancient Egyptians, wooden coffins used by them, estimated to be at the very least 2,000 years old, having been found in good preservation. Wooden dowel-pins were also employed in the stonework of the ancient Egyptian temples, the age of which is undoubtedly over 4,000 years. These latter are probably the oldest pieces of wood existing in the world at the present time, and are thought to have been treated with some preservative agent, probably bitumen.

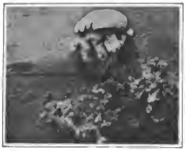

Fig. 1.—Wood-destroying fungus (Lentinus Lepidus) on fir tie.

Among the pioneer investigators into the subject of preservative agents was Johann Glauber, of Carlsbad, Germany, a celebrated chemist in his day. Glauber's experiments were made about 1657, and his process consisted in first carbonizing the wood under the action of fire, then coating the surface with tar, and subsequently immersing the wood so treated in pyroligneous acid or crude acetic acid.

Since the date of Glauber's experiments, numerous processes for the preservation of wood have been devised, many of which would doubtless be efficient for the purpose, the only question being the commercial one as to the possibility of economical application. The earlier investigators, however, whose processes gave the most satisfactory results, were those who carried out their experiments in the decade between the years 1830 and 1840, and three processes dating from that period have survived to the present time, viz., the corrosive sublimate or mercuric chloride ($HgCl_2$), or kyanizing process; the dead oil of tar or creosote oil, or creosoting process; and the chloride of zinc ($ZnCl_2$), or burnettizing process. The first, or kyanizing process, is now less frequently employed owing to the greater cost of the agent and the longer time required to carry it out.

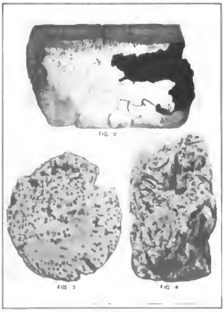

Fig. 2.—Growth of destructive fungus on untreated white oak tie. Figs. 3 and 4.—Untreated oak piles destroyed by Teredo Navalis, the latter after only two years' service.

The first experimenter to employ pressure for the purpose of forcing antiseptics into wood by means of hydraulic pressure is said to have been a Frenchman named Breant in 1831. In 1846 the plan of previously steaming the wood was introduced by Pain.

CONDITIONS NECESSARY TO INSURE SUCCESS.

Two conditions are absolutely necessary in order that an antiseptic agent should produce useful results in the preservation of wood, viz., a proper liquid state at the instant at which injection into the wood takes place, and a reasonable cost.

It is also essential that the operator should have a thorough insight into the practical working of the process employed, and a knowledge of the nature of the preservative used.

The wood to be treated should, moreover, be in a proper condition, that is to say, properly seasoned or at the very least half seasoned. In the best practice in Europe the wood is not treated until it has been seasoned from six to twelve months. In the United States, however, wood is usually treated from four to six months after cutting, and generally with inferior results.

THE ABSORPTION OF PRESERVATIVES BY TIMBER.

The whole problem involved in timber preservation is the replacement of the sap of the wood by some suitable preservative agent, and before proceeding to discuss the various antiseptics and systems of application employed, a few observations upon the fundamental factors controlling the penetration of preservatives into wood may materially assist in clearing away some of the difficulties that occasionally confront those interested in the timber-preserving industry, through results being obtained in practical working which cannot be satisfactorily explained.

With this object in view the writer thinks that he cannot do better than give some brief abstracts from two papers on "The Preservative Treatment of Wood," by Mr. Irving W. Bailey, Assistant Professor of Wood Technology, Harvard School of Forestry, which papers appeared as contributions from the laboratory of wood technology of the above school, in a recent number (Vol. XI, No. 1, March, 1913) of the *Forestry Quarterly*, a professional journal published in Ithaca, N. Y. The writer has to thank Prof. Bailey for his courtesy in lending him the original negatives, so as to enable him to take prints from which the photomicrographs Figs. 5 and 7 have been prepared, and he would also observe that the above papers would well repay perusal *in extenso* by those interested in the subject.

The first of these articles treats of the validity of certain theories concerning the penetration of gases and preservatives into seasoned wood. The author analyzes Tiemann's theory, which he summaries as follows: "In fresh green wood of all species the cells of all kinds (except the resin ducts and the vessels) are completely closed by the primary wall, and the gases cannot be forced through this inclosing membrane even at extreme pressures. Water may percolate through this membrane gradually, as through a filter, but this action must be comparatively slow even under high pressure. . . . Whenever wood seasons (beyond its fiber saturation point), whether naturally or by artificial means, narrow microscopical slits occur in the walls of the fibers and tracheids which render them penetrable to gases and liquids. These slits do not reunite when the wood is resoaked, although they may close up somewhat. The greater the degree of dryness the more penetrable the wood becomes. . . . Steaming opens up these slits in the cell walls, but they are not as numerous nor as wide as in air-dried material."

The greater penetration of creosote in dense woods and in heavy "summer-wood" of long-leaf pine paving-blocks is explained by Mr. H. F. Weiss by the fact that dense tissue cracks more in drying. Such splitting, he says, does not occur to the same extent on the light thin walls, as they seem to yield and bend more under readjustment of the wood during drying. The heavy walls it seems, therefore, cannot readily adjust themselves to moisture changes, and consequently split somewhat in the manner of a tie when it dries too rapidly.

The subject is discussed at some length, the following summary and conclusions having been arrived at:

1. Spiral cracks in the walls of tracheids and fibers occur in only a small percentage of dry wood.
2. Spiral cracks, when present, are confined in ce-

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* Paper read before the Royal Society of Arts and published in its Journal.

niferous woods to the heavy, thick-walled tracheids at the end of the year's growth.

3. Spiral cracks are confined to the secondary and tertiary layers of the cell wall, and the primary wall remains unruptured.

4. Air passes as easily through dry cells whose walls are unruptured as through cells whose secondary walls have cracked in drying.

5. In many cases air cannot be passed through dried cells whose secondary walls possess well-developed "slits," or cracks.

6. Although drying cracks or "slits" do not close when dry wood is thoroughly resoaked, resoaked wood is in many cases as impervious to air as unseasoned material.

7. Although air cannot be forced through long pieces of green coniferous wood even under heavy pressures, it passes in many cases through short pieces of more than one fiber length.

8. In long-leaf pine paving-blocks, when the penetration was confined largely to the dense bands of "Summer-wood," the walls of the latter were, in the majority of cases, found to be unruptured.

From this it is held to be clear that Tiemann's "slit" hypothesis cannot account for the penetration of gases and oils into seasoned woods. Similarly, Weiss's theory cannot account for the greater penetration of preservatives into dense tissues. In both cases some undetermined factor, or factors, are at work which control the injection phenomena.

Fig. 5 shows at *D* a radial longitudinal section of a western hard pine showing spiral cracks or "slits" in the thick walls of the "Summer-wood." The thin-walled spring tracheid at the right is seen to be unruptured. (*E*) A cross section of the dense fibers of a broad-leaved tree, or "hardwood," showing drying cracks in the thick secondary walls. The darker colored primary walls which inclose the inner layer are seen to be unruptured. (*F*) A tangential longitudinal section of the "Summer-wood" of western yellow pine showing spiral cracks or "slits." (*G*) A cross section of both the "Summer" and "Spring-wood" of a Mexican hard pine. The cracks or "slits" are confined to the thick secondary wall of the "Summer-wood." The dark primary walls are seen to be unruptured. (*H*) A longitudinal section of freshly-cut white pine sap-wood, taken from the immediate vicinity of the cambium, showing the fine spiral bands which occur in specialized cells that resist compression. (*J*) A longitudinal section of loblolly pine tracheids, showing striated effect produced by incipient stages of decay. (*K*) A cross section of the air-dried "Summer-wood" of a very dense specimen of long-leaf pine. The thick secondary wall, as well as the primary and tertiary walls, is seen to be unruptured (compare *G*). The first faint lines crossing the section from right to left were made by the minute irregularities which occur on the edge of even the sharpest microtome knife.

In the second article, Mr. Bailey deals with the structure of the pit membranes in the tracheids of conifers, and their relation to the penetration of gases, liquids, and finely-divided solids, into green and seasoned wood, the following summary and conclusions being arrived at:

1. Wood is a highly specialized and complex plant tissue, designed primarily to conduct aqueous solutions and to give strength and rigidity to stem and branches.

2. It is extremely variable in different species and even in different parts of the same individual, owing to variations in the functions which it is called upon to perform.

3. Coniferous woods, or "soft woods," are composed largely of minute cells, or tubes, with closed ends. Liquids, in passing through this tissue, travel primarily in the cavities of the cells, and pass from cell to cell by means of delicately constructed valves or bordered pits in the cell walls.

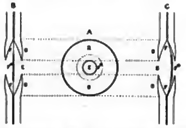

Fig. 6.—Diagram showing structure of bordered pit.

4. The membranes of the bordered pits are not always entire, as has been previously supposed, but possess (in all species examined) numerous minute perforations, whose presence may be demonstrated by careful microscopic examination and by experimental means.

5. When wood is thoroughly dried, no structural modification, such as the rupturing of the cell walls, is essential in order to account for the penetration of gases and preservatives into seasoned wood.

6. In green wood, the bordered pits and membranes are very permeable to aqueous solutions, but are comparatively impervious to undissolved gases, and to oils, and other heavy or viscous liquids. This is due, undoubtedly, to capillary or surface tension phenomena and the valve-like action of the torus.

7. Dry wood (except when the cells are clogged with resins or other secretions) is very permeable to gases, since water is no longer present to resist the passage of the gases through the perforations in the pit membranes.

8. Whenever preservatives are injected rapidly into green or seasoned wood, the penetration takes place primarily through the cavities of the cells, and the preservatives pass from one cell to another through the bordered pits.

9. Rupturing of the pit membranes was found in some specimens to be concomitant with the process of drying, and may account for the fact that in certain cases resoaked dry wood is less impervious to air than green material.

10. The impregnation of wood by modern commercial methods is a complicated chemical, physical, and anatomical problem, since any given phenomenon may be the result of numerous interesting chemical, physical, and anatomical factors.

Fig. 6 shows diagrammatically the structure of bordered pit: *A* being a surface view of bordered pit; *B* and *C*, sectional views of bordered pits; *D*, embossed or bordered area of secondary wall; *E*, pit or orifice in secondary wall; *F*, membrane; *F**, thickened area of membrane or torus.

Fig. 7 shows at *L* a tangential section of sequoia showing sectional view of the bordered pits. The membrane and torus are seen to occupy a medium position between the two arching cell walls. (*M*) Tangential section of hard pine showing sectional view of bordered pits. The tori have been pressed against the left-hand orifices by excessive pressure. (*N*) Tangential section of hard pine showing sectional view of bordered pits. The torus in this case is thin and flexible and has been jammed into the right-hand orifice so firmly that it appears bow-shaped. (*O*) Tangential section of freshly cut green white pine sapwood injected with a carbon mass. The minute carbon particles are seen to penetrate from one cell to another by the bordered pits. (*P*) Tangential section of sequoia heartwood showing the penetration of carbon mass from one tracheid to another through the numerous bordered pits. (*R*) Tangential section of the Summer-wood of a common long-leaf pine paving block. The heavy tar oils are seen to penetrate by means of the bordered pits. (*S*) Diagrammatic drawing of pit membrane and torus. The perforations are seen to occur in the thinner bands of membrane substance. (*T*) Radial section of freshly cut green white pine sapwood treated with a carbon mass. The carbon particles are seen to penetrate the pit membrane in a rim about the torus, and in lines radiating outward from it. (*U*) Radial section of larch showing large perforations in the pit membranes.

VARIOUS PROCESSES EMPLOYED FOR PRESERVING WOOD.

The Bichloride of Mercury Process or "Kyanizing."—The preservative process usually known as "kyanizing," from the name of the inventor, John Howard Kyan, who introduced it into this country in the year 1832, consists in steeping or soaking the wood in a solution of bichloride of mercury or corrosive sublimate ($HgCl_2$), the solution generally used consisting of 1 pound of the salt to 10 pounds of water.

In the year 1836 this process was introduced to Woolwich by the Royal Engineers, but it has now practically gone out of use in England. The chief objections to the process are the high cost of the agent, and that, being carried out without pressure, it is a very slow one, occupying as many days as the pressure processes do hours. According to Mr. Samuel M. Rowe, an authority on the preservation of timber in America, the usual rule there—where the process has recently been carried on in some localities owing to chloride of zinc and dead oil of tar or creosote oil for the "burnettizing" and creosoting processes not being readily available—is to allow the wood to steep in vats for a length of time depending upon its least thickness, thus if the timber is 10 inches by 12 inches thick it would remain in the vats eleven days; if 6 inches by 9 inches it would steep for seven days.

Owing to the bichloride of mercury used as the antiseptic in this process containing hydrochloric or muriatic acid (HCl), which acts injuriously on iron, it has been found impracticable to attempt to impregnate the wood under pressure.

The price of corrosive sublimate is about 3s. 6d. per pound, against 4d. per gallon for creosote oil, and about 2d. per pound for pure chloride of zinc.

The Zinc-chloride Process or "Burnettizing."—Sir William Burnett's invention, known as "burnettizing," was introduced in 1838, and the process consists briefly in the destruction of the tendency possessed by certain vegetable and animal substances to decay, by subjecting them to the action of chloride of zinc ($ZnCl_2$). The degree of dilution recommended by the inventor is 1 part by volume to 50 parts of water, and the impregnation is now most commonly carried out under a pressure of 7 or 8 atmospheres, as used in creosoting. In Germany, where the process is probably the most used, the wood is steamed under a pressure of from 60 pounds to 70 pounds per square inch, preparatory to burnettizing. The solution employed is generally composed of 2.5 per cent of zinc chloride and 97.5 per cent of water.

In the United States the solution most commonly used consists of 0.5 pound of dry zinc per cubic foot of wood treated. The wood to be treated is first air-seasoned in the open or steamed in closed retorts to expel moisture. The first stage of the cycle consists in

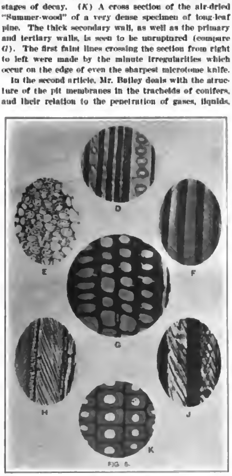

Fig. 5.—Photomicrographs illustrating validity of slit hypothesis.

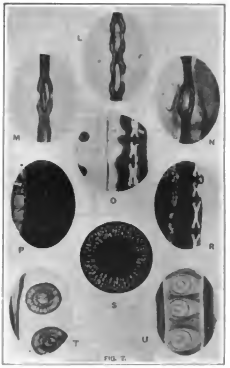

Fig. 7.—Photomicrographs illustrating structure of pit membranes in conifers.

subjecting the wood in the retort to a vacuum, which is maintained until the solution is introduced, and the wood is completely submerged. Additional solution is then pumped in and the pressure increased to about 100 pounds or 125 pounds per square inch, until the required amount of penetration and impregnation is obtained, and the remaining solution is then drained from the retort.

The solution used consists of a combination of zinc spelter with hydrochloric acid, leaving no free acid. The strength of the solution is perhaps best arrived at by experiments with the particular wood to be treated.

It is important that the zinc-chloride should be as free from all impurities of any kind as is practicable, being basic and devoid of free acid. The commercial chloride is dissolved, shortly before being required for use, into a concentrated stock solution from 35 to 50 per cent in strength to insure thorough dissolving, any free acid being taken up by the spelter placed in the vat. The diluted solution is made by the addition of the requisite amount of water to this stock solution, the most convenient method of testing the strength of the solution being the Beaumé hydrometer.

The full programme of the process is as follows: Steaming to 20 pounds pressure per square inch for 30 minutes; steaming from 20 pounds to 35 pounds pressure per square inch for 3 hours 30 minutes; blowing off steam, 15 minutes; vacuum, 45 minutes; solution to about 100 pounds pressure per square inch, 45 minutes; solution maintained at 100 pounds pressure per square inch, 1 hour 15 minutes; forcing back solution, 15 minutes; total time, 7 hours 15 minutes; or, if the steaming time be reduced by 2 hours, 5 hours 15 minutes.

The principal recommendation possessed by this agent is that of cheapness. It possesses no value for the protection of piles or timber against the attack of marine worms, although it is said to be useful as an aid to the impregnation of piles, etc., with creosote.

When timber impregnated with zinc-chloride is subjected to wet, a certain amount of the agent washes or leaches out, the percentage of loss gradually diminishing. This last does not appear, however, on investigation to be so serious a matter as it would seem at first sight. Experiments, described in the *Engineering News*, made by Mr. Octave Chanute with wood treated by the zinc-chloride process, during which efforts were made to extract the preservative by long-continued and oft-repeated series of immersions in water, showed on drying and analyzing that, although a small, regularly decreasing amount does waste out, after about 18 months of strenuous treatment, only 28 per cent of that originally absorbed was extracted.

The appliances required for carrying out the zinc-chloride process are practically the same as those used for "creosoting," except that for the latter process a storage tank will be required for receiving the oil, and that the retort or impregnating cylinder is fitted with steam-heating pipes to maintain the necessary fluidity of the oil. The main pipes through which the oil is passed should also, for the latter process, be heated by internal steam-pipes for the same purpose.

The Zinc-tannin or Wellhouse Process.—This process consists in subjecting the wood to be treated to the action of steam in a retort or impregnating cylinder for a period sufficient to open the pores and expel the natural saps, followed by a vacuum of from 18 to 26 inches to withdraw the vapors and free the wood from the condensed steam and volatilized saps. The antiseptic agent consists of a solution of zinc-chloride of a strength of from 1.5 to 3 per cent, according to the nature of the wood, with a proportion of dissolved glue equal to one half of 1 per cent. (The Allis-Chalmers Company gives the proportions as 0.5 pound of dry zinc-chloride plus 0.5 per cent of glue or gelatine per cubic foot of wood.) The solution is held in the retort at a pressure of from 100 pounds to 125 pounds per square inch for 2½ to 6 hours, after which it is forced back into the storage tank and a ½ per cent solution of tannin or tannic acid ($C_nH_mO_n$) is introduced and held under the same pressure as before for about two hours. After the withdrawal of the latter the operation is complete.

In some works the practice of introducing the glue in a separate solution is adopted: this necessitates the provision of another storage tank.

The zinc-chloride solution is the same as used in the zinc-chloride process. The glue employed is the ordinary article of commerce; those glues, however, having the highest percentage of gelatine being preferable. The tannic acid generally consists of an extract of hemlock bark. From 25 to 30 per cent of pure tannic acid should be present. The amount of the glue and tannin should be one tenth of the amount of pure chloride used, the proportions of glue and tannin being such as to insure the absorption of the prescribed amount of pure chloride per cubic foot of wood. The amount of glue should be at least 1 per cent in weight of the whole amount of chloride solution. The strength of the tannin solution should be at least 1 per cent in weight of the whole contents holding the tannin solution.

The time occupied in treating the wood by this process is, for ties or sleepers, omitting steaming, 4½ hours, with steaming, 6½ to 8½ hours; for timber, omitting steaming, 5½ hours, with steaming, 8½ to 13½ hours.

The zinc-tannin process differs only from the "burnettizing" process in the addition of the glue and the subsequent treatment with tannin solution. The glue and tannic acid combine and form a leathery and insoluble product claimed to assist in rendering the wood impervious to the absorption and giving off of moisture, and thus to prevent the zinc-chloride from leaking or being washed out.

The plant required for the zinc-tannin wood-preserving process is practically the same as that used for the "burnettizing process.

(*To be continued.*)

Tires*

The tire is a highly important factor in motor car operation, and safety in the handling of the car can hardly be expected unless the tires are kept in good condition. The cost of a new set of tires is so heavy that owners are tempted to postpone renewal as long as they can persuade themselves that it is safe to do so, and economy and safety are therefore closely related, when the tire problem is under consideration. Ever since the introduction of the automobile, manufacturers and owners of cars have sought a substitute for the expensive rubber, and the rapidly increasing use of the automobile has emphasized this demand and made it more insistent. The numerous rewards and prizes that have been offered for the discovery of a cheap and satisfactory substitute, and the alluring promise of commercial gain that such a discovery holds out, have stimulated inventive minds to a wonderful degree, and have resulted in the exploiting of a number of substances; but none of them, so far as we know, has yet demonstrated its value by protracted experience, and the prospect is that rubber will remain king for a long time to come.

It is almost impossible to give a definite and reliable estimate of the average percentage of the total maintenance cost of an automobile that can properly be charged to tires. Figures have been given, however, in which the tire item ranges from 20 per cent to 50 per cent for commercial cars, and between similar limits for pleasure cars. This wide variation is due to the many factors that determine the life of a tire. The size of the tire, the weight of the wheel and of the car, the speed of operation, the condition of the roadway, and numerous other things, all have a direct bearing upon the tire mileage, and it is easy to see that the tire problem must necessarily be a complex and difficult one. The mileage may be greatly increased, however, by heeding the advice given by the tire manufacturers, and by exercising good judgment in the care of the tires.

A familiar example of poor judgment, which may be seen almost any day in our cities, consists in running a car up too close to the curb. Some drivers take pride in their ability to bring a passenger car so close to the curb that there is barely a crack left between the two; but it is unwise to practise this, because a slight miscalculation will cause the front wheel to rub against the curbstone, and the rear wheel on the same side is usually subject to a similar rub when the car turns out into the street again. The abrasion caused by the friction of the tire with the rough surface of the curbstone weakens that section of the tire, and continued action of this kind may reduce the strength of the casing so materially that a blow-out will soon follow, perhaps with serious consequences. A driver who stops his car at a distance of one foot from the curb certainly avoids the risk of injuring the tires; and although we emphatically disclaim any exact knowledge of the distance that a woman can step in a modern narrow skirt, we strongly suspect that she could negotiate an interval of twelve inches without danger, even if she were clothed in the extremest of the feminine fashions of the day.

The wear on the tires depends to a large extent upon the nature of the road, the weight of the wheels, and the speed at which the car is run. In general, the heavier the wheel the higher its rebound when it meets an obstruction. Between the instant that the wheels leave the roadway and the instant that they touch it again they are free from the friction of road contact, and during this brief interval the load on the engine is released. Hence there is a momentary speeding up of the driving wheels. When they again come in contact with the road they are revolving faster than when they left it, and they must therefore slip to some extent before they are again turning in conformity with the speed of the car. This action may be imperceptible in any one case, but the aggregate effect of it during, say, 5,000 miles of travel is serious, and distinctly detrimental to the tires.

Many persons neglect to inflate their tires to the pressure recommended by the manufacturers, because the car rides more comfortably on under-inflated tires. This is a mistake, as insufficient inflation shortens the life of the tires, and causes a great deal of trouble. Rim-cutting is the usual result of insufficient pressure, and if the car is heavily loaded the tires may be damaged beyond repair in a comparatively short time.

In addition to tire deterioration from the causes mentioned above, there is the ever-present danger of a cut or a puncture. A tire coming in contact with an object having a cutting edge is likely to receive a more or less damaging slit, which unless it is promptly repaired, gradually extends and weakens the shoe. It is then only a question of time before a blow-out occurs. Small punctures are less serious than blowouts, but they are very annoying, especially on hot, dusty days, and a great deal of ingenuity has been expended in the effort to produce a puncture-proof tire. The difficulty is, to obtain a durable and reliable tire, of reasonable cost and simple construction, without sacrificing resilience.

Many automobile accidents are due to the skidding or slipping of the wheels. When a driver is obliged to make a sudden stop or turn while running on a slippery pavement the chances are that the car will slip or skid before responding properly to his efforts. The skidding is most marked when the rear wheels spin around on account of the roadbed being slippery, resistance to sidewise displacement being greatly reduced, in accordance with well-known mechanical principles, by the rapid rotational slipping. In order to minimize dangers of this kind, tire manufacturers have placed on the market so-called non-skidding or non-slipping tires. Various designs are used by the different makers, but the general idea is to mold a series of projections on the face of the tire, so as to roughen its surface and enable it to seize more effectively upon the irregularities of the road. Chain attachments are quite commonly employed for the same purpose, and they are especially useful in winter, because they not only diminish the skidding, but also increase the tractive power of the car in snow and mud.

Attention to the following suggestions will materially prolong the life of the tires, and will thereby promote safety also.

Care should be taken to avoid letting the clutch in quickly when the car is at rest, because the sudden application of power may make the rear wheels revolve rapidly before the car gets under way, and causes serious and totally needless wear on the tires. A similar effect is produced by applying the brakes too suddenly when the car is in motion, and thereby locking the rear wheels so that the car slides. It is injurious to the tires to run on them when they are flat, or to drive on the rails of street car tracks, or to operate the car, at high speed, over roads covered with loose stones or across street car rails that are raised above the road level. Small cuts should be promptly repaired, and a reliable gage should be used when blowing up the tires, so that the pressure to which they are filled may be properly regulated. Oil and grease are very destructive to rubber, and the tires should be protected from contact with them. At the end of a journey the tires should be carefully wiped off, to remove any oil that may have accumulated upon them while driving over oiled roads; and the car should not be allowed to stand where there are pools of water or oil on the floor or the ground. If a blowout or a serious puncture occurs on the road, and the driver has no more inner tubes, it is sometimes advantageous to remove the damaged tube and fill the casing as solidly as possible with hay or grass or some other similar material. An expedient of this kind should not be adopted unless the situation is serious, but it is better than attempting to run on the flat casing, or on the rim of the wheel after the casing has been removed. It is hardly necessary to state that the car should be driven slowly and carefully while operating under these conditions, and that repairs should be made, or new tires procured, at the earliest opportunity.

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* Reproduced from *The Travelers Standard*.

The Electrical Conductivity of Copper

The electrical conductivity of copper depends upon the total amount of impurities, and not upon any one element. This is why the conductivity test is so valuable in determining the purity of copper. The aggregate of all impurities is shown, and thus the purity of the copper indicated. Amounts of impurities that will defy detection, or would never be known to exist by chemical analysis, are found when the electrical conductivity test is applied.

A New Wright Aeroboat

A Marine Aeroplane of the Pontoon Type

The latest Wright aeroboat known as type "G" belongs to the class of three pontoon marine aeroplanes, the center pontoon, or hull, furnishing most of the flotation, while the smaller pontoons attached to either wing end do their share in supporting the craft. No special hydroplane paddles, however, are attached to these auxiliary end pontoons, as their use has been found unnecessary.

The motor seats and other parts are placed entirely above the deck which seals the top of the pontoon. At the same time the sides of the hull are carried above this watertight deck to the height of the wings, and form an enclosed body for the motor and seats, protecting them very effectively from spray and waves.

The motor is situated in the front, motorcar fashion, and the seats, side by side, are back of the motor and situated at the center of the wings. At the rear of the main wings are the two propellers, and beyond these the rudders, which are carried on a tail frame, from the center section.

Under the seats and above the step of the hydroplane pontoon are large air tubes, which pass from the deck through the bottom of the hull. These tubes serve not only to ventilate the step, but to drain the cock-pit in which the seats are located, of any water shipped in bad weather. This feature is similar in arrangement to that of self-bailing lifeboats.

It is interesting to note that in tests of the Navy aeroboat made at Toledo recently, the passenger carried was able quite easily to open up the engine hatches, examine the engine while in flight, and make minor adjustments. It would even be possible to replace spark plugs while the machine is in operation in the air.

The boat hull itself is 19 feet long, and at its widest has a beam of 43 inches. The height of the hull is such as to give a clearance to the tips of the wings of 3½ feet above the water surface when hydroplaning, which gives splendid rough sea qualities, and makes the possibility of catching a wing in rough water quite remote. Over the engine the metal covering is made in the form of two large hatches, which slide in and out. When removed these hatches give access to the engine, and when closed serve as a practical watertight covering. With this arrangement built as strongly as it is on the new aeroboat, it is possible for the craft to plunge head-on into a large wave without having the water stop the running of the engine or causing any detrimental effect.

The wings of the aeroboat are 38 feet in span and 6 feet in chord, with a distance between planes of 5 feet. The main carrying surface is 430 square feet in area. The interior construction of the wings themselves, like most other details in the machine, has been much improved over previous practice. The ribs are made solid of I-beam shape, and the spars are increased in depth. The thickness of the wing is very much greater than in previous designs, thus adding to the strength. The wings are covered with a special grade of linen, treated with a preparation which gives to the linen a smooth finish that is not only weatherproof, but is proof against seas. The struts, of a splendid streamline form, are of ample cross-section, and the important sustaining wires throughout the craft are doubled, there having been introduced an entire duplicate system for the main warping wires as well.

An interesting feature in connection with the wing construction is the new type of joints adopted for connecting the wires to the struts and planes. These joints consist simply of a hook-shaped plate of great strength, into which the eye of the wire fits. This has permitted of the entire elimination of the number of bolts and pins which are ordinarily employed, and has thereby greatly increased the safety of the machine.

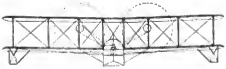
It is of importance to note that the wings are not divided at the center, as is customary, the spars at the boat being continuous, from one wing to the other. This feature has eliminated the body joints, which are a source not only of added weight, but of considerable danger because of the great strains at this point.

At the tips of the wings are mounted on either side the auxiliary pontoons, which help to float the machine. These pontoons are attached to the lower wing spars by strong steel braces, and are themselves merely smaller duplicates of the central boat in construction.

The control of the wings and rudders in the new type is in duplicate, and provision has been made for mounting either the customary Wright lever control or the new Wright wheel control.

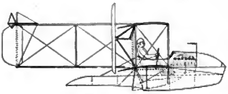
The rudders of the Wright aeroboat are exceedingly novel in form and very powerful in size. The rudders for the direction of the machine are pivoted on two steel tubes, which form the rear struts of the tail frame supporting the rudders, a convenient arrangement which has helped greatly to reduce head resistance. These twin rudders work in unison, being suitably connected by cross wires. The area of the direction rudders totals over 22 square feet.

The elevator, of the new Wright inherent stability type, is carried very high, being attached to the top of the rectangular tail frame above the two rudders. This feature has greatly added to the natural tendency in the balance of the machine to overcome the high thrust of the propellers. The elevator in type "G" has 16 feet span and a total area of 53 square feet. The construction of both the elevator and the rudders is similar to that of the wings, and ample bracing has been provided to avoid vibration.



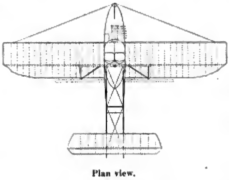
Front view of Wright aeroboat.

The transmission on the new Wright aeroboat has introduced many refined engineering problems, in which the experience of the Wrights in this kind of work has resulted in a remarkably successful drive. As customary in Wright practice, two propellers are used, rotating in opposite directions, and, in the case of the aeroboat, the increase in efficiency that is obtained thereby is even more valuable than on land machines. The propellers are 8 feet 6 inches in diameter, and rotate approximately at 580 revolutions per minute. They are driven by chains from the central drive shaft, one of the chains being crossed. The shafts are so distanced by guides and radius rods as to permit of easy alinement.



Side elevation.

The central drive shaft passing under the seat drives the propellers from the engine, situated in front. At the front end there is mounted the new Wright shock-absorbing drive, a feature new to aviation, which is an application of the highest engineering principles, and is a step in the progress of aeroplane construction that has considerable significance. This shaft carries at its end a steel cone upon which are mounted pins. On the flywheel of the engine similar pins are mounted, and connection between these and the pins on the shaft is made by eight shock absorbers. The shaft cone is free to rotate in relation to the flywheel, but the two are restrained by the shock absorbers, these being the only direct connection between the engine and the transmission. As a consequence, the power of the engine is entirely transmitted to the rest of the machine by these shock absorbers. The introduction of this elastic element has not only rendered it possible to greatly reduce the weight necessary in the transmission to resist the severe strains of the engine, but has also greatly lengthened the life of the mechanism.



Plan view.

The weight of the entire aeroboat, empty, is 1,300 pounds, a record in construction in machines of this size and strength. The motor is a 6-cylinder 60 horsepower Wright.

The speed range of the machine is in the neighborhood of 40 to 60 miles an hour, and splendid climbing ability has been shown. On many occasions three people have been lifted with ease, and the scores of passenger flights that Harry N. Atwood has already made with his aeroboat, as well as his splendid trips from Toledo to Detroit, have proved the worth of the new type.

An Early Slide Rule

David Baxandall, writing in *Nature*, says: "De Morgan, in article 'Slide Rule' in the *Penny Cyclopædia*, points out that though Gunter first used a logarithmic scale, the real inventor of the logarithmic slide was Oughtred. 'In the year 1630 he showed it to his pupil, William Forster, who obtained his consent to translate and publish his own description of the instrument, and rules for using it. This was done under the following title, "The Circles of Proportion and the Horizontal Instrument," London, 1632; followed in 1633, by an "Addition, etc.," with an appendix having title, "The Declaration of the two Rulers for Calculation."' After referring to a republication of this work in 1660, he goes on: 'The next writer whom we can find is Seth Partridge, in a "Description, etc., of the Double Scale of Proportion," London, 1685. He studiously conceals Oughtred's name; the rulers of the latter were separate, and made to keep together in sliding by the hand; perhaps Partridge considered the invention his own, in right of one ruler sliding between two others kept together by bits of brass.'

"Prof. F. Cajori, in his book, 'A History of the Logarithmic Slide Rule,' 1909, the result of an exhaustive inquiry into the literature of the subject, quotes De Morgan, and continues (p. 17), 'To Partridge we owe, then, the invention of the slide.' In an addendum (p. vi), he refers to a copy of Partridge's book in his own possession, published in 1662, in which it is stated that the book was written in 1657.

"Dr. Alexander Russell, in *Nature*, January 30th, 1910, p. 307, states: 'A few years before 1671, Seth Partridge rediscovered the sliding principle, perfected it, and gave an almost complete specification for the slide rule which is used to-day by engineers. . . . Personally, I consider that Seth Partridge is the real inventor of the modern 10-inch slide rule.'

"My object in writing is to direct attention to the fact that there is in the Science Museum at South Kensington a slide rule which is inscribed, 'Made by Robert Bissaker for T. W., 1654.' This proves that the slide was invented and *in use* three years before Partridge wrote his pamphlet, and eight years before the earliest known date of its publication.

"This very early example of the instrument is of boxwood, well made, and bound together with brass at the two ends. It is of the square type, a little more than 2 feet in length, and bears the logarithmic lines first described by Edmund Gunter. Of these, the *num.*, *sin.*, and *tan* lines are arranged in pairs, identical and contiguous, one line in each pair being on the fixed part, and the other on the slide. As Seth Partridge describes no feature which is not embodied in this example of the instrument, it would appear that less credit is due to him for invention in connection with the slide rule than has hitherto been given.

"In this year of the Napier tercentenary celebration it is interesting to know that a slide rule is still in existence which was made only forty years after the invention of logarithms."

A Long Rope Railway

A rope railway, 75 miles in length, is to be put in operation in India. It will connect the rich country in the Vale of Kashmir with the plains of the Punjab over the Himalayas. The line, it is claimed, will be the longest in the world, the present longest being 22 miles and situated in Argentina. Sections will be 5 miles long, and most of the spans will be 2,400 feet. The steel towers, some of which will be 100 feet high, will be braced, and double 1½-inch cables, 9 feet apart, will carry the steel cars. The carrying capacity of these cars will be about 400 pounds.

View of two of the machinery halls at the exhibition.

A World's Fair of Books

The International Exposition of Book Trade and the Graphic Arts at Leipzig, Germany

By Dr. Alfred Gradenwitz

On the very ground where, one hundred years ago, was waged the "nations' battle," a peaceful competition of peoples is taking place this year, for the benefit of civilization and the profit of mankind. The International Exposition of Book Trade and the Graphic Arts, at Leipzig, Germany, may fitly be called a symposium on human education; it unfolds before our eyes the history of culture, man's own history, giving an insight into the intellectual evolution of nations, the rise from darkness, superstition, and ignorance to light and joy, education, knowledge, and understanding.

No other city in the world could afford a more fitting and dignified frame for a world-fair such as this, than the ancient metropolis of the world's book trade, which in addition to its old traditions, boasts of a goodly number of important publishing firms and professional associations and schools. The idea of this exposition therefore awoke an enthusiastic echo in the population of Leipzig, and was greeted with joy by the profession, in Germany as well as abroad. It was soon realized that greater things than in the case of the average exposition were at stake, and the foremost experts, scientists, and artists willingly lent their assistance. The same appreciation was shown abroad, and no civilized country having achieved anything of importance in the field of book trade and the graphic arts was content to lag behind in the race.

The "World's Fair of Books" coincides with the 150 years' jubilee of the Royal Academy of Graphic Arts and Book Trade of Leipzig, which year after year sends out so many artistically trained members of the profession.

The spirit of the underlying idea finds a dignified expression in the architectural arrangement of the exposition. On entering by the main gate, leading to "October 18th Street," one obtains a splendid view of the exhibition grounds, while in the background the Leipzig Battle Monument looms up. To the right of this avenue, which is one of the main thoroughfares, traversing the whole length of the exposition, there is situated the extensive group of buildings constituting the German Main Hall, the heart, as it were, of the whole show. This hall covers an area of five acres, and comprises practically all branches of the printing and publishing industry.

The right hand wing of the imposing building is given up entirely to the extensive field of German book trade and kindred industries, inclusive of the arts of repro-

A variety of architectural styles are represented on the exhibition grounds.

The merchants' building.

The hall of civilization.

One of the exhibition pavilions.

The hall of paper industry.

duction, photography, and kinematography. We are shown, among other things, how the artist designs an alphabet, how the engraver copies it, and how the type is cast ready for the compositor. We may watch how the type and blocks are combined in the typesetting machines, to form the most varied typographic products; how the compositor's work is corrected and made ready for printing. The various modern printing processes in use are likewise exhibited.

In the central part of the building are housed, among other groups, those of bibliography, library, science, bibliophily, etc. The most beautiful products of German book-binding and the exhibits of the Imperial Printing Offices and German Patent Office are found there, in addition to the large Book Sales Exposition.

The whole left-hand wing and part of the rear of the building are taken up by a pantheon of the German publishing trade, where an adequate idea of the imposing number of books and musical editions brought out every year can be gained. The hall set apart for illustrated magazines is likewise found in this wing, and adjoining it is the Musical Editions' Sales Department, comprising a large hall for musical and literary recital.

On leaving the German Main Hall from the rear, we reach a square known as Gutenberg Square, on which are situated three huge engine halls, covering a total of 18,000 square meters. In the first engine hall a paper-making plant is shown in operation. In the second engine hall, printing, typesetting, and casting machines are similarly exhibited. The third engine hall shows, among other things, a large up-to-date book-binding shop, comprising about fifty auxiliary machines, in full operation. Foreign firms are largely represented in the first and second engine halls.

The intellectual center of the show is formed by the Hall of Civilization, on the left of Gutenberg Square, where the gradual development of the book trade and graphic arts with their forerunners in the various stages of civilization with all the peoples of history is shown in a comprehensive exhibit.

In three large annexes to the Hall of Civilization are housed two of the most important groups of the exposition, namely, the Departments of Graphic and Photographic Arts, respectively. The former comprises masterpieces of the contemporary graphic art of practically all civilized countries, and gives an excellent idea of what is being achieved at the present day in the field of etching, engraving on copper, artistic wood engraving, modern lithography, etc. Applied graphics, as exhibited in book-binding, artistic lettering, etc., is likewise represented, much room being devoted to book illustration. Photography as a free art is comprehensively represented in a huge hall, mainly as professional photography, though the amateur's art also finds a place. Nor are the very latest manifestations of the art, such as balloon and aeroplane photography, omitted. The scientific evolution of photographic art and its resources, as well as the latest advances, including the whole of kinematography and the manifold scientific uses of ordinary and moving-picture photography, are likewise on show.

"Nations' Street," a long avenue on which are situated the palaces of the nations participating on an especially large scale, leads from the Hall of Civilization to the second entrance to the exposition. On the right are seen the Italian and French buildings, two white pavilions designed in renaissance style. Between these, somewhat to the back, there is the huge hall housing a special international show, "The Business Man," where among other things, the evolution of commercial education, from its most primitive beginnings to its present perfection and variety, is illustrated. On the opposite side of the street is the Esperanto pavilion, a building devoted to "German Civilization Abroad," "German Colonies," etc., and finally, a pavilion where Japanese wood-cutters are demonstrating their art. On the right-hand side of this street is the Saxon State Building, where the Royal Academy of Graphic Arts and Book Trade, as well as the Bourse Association of German Booksellers, have some most excellent material on show; further, the Austrian State Building, and between the two, in the background, a special exposition, "Picturesque Germany," where the choicest spots of the country are shown in photography. On the opposite side, beside the Wine Restaurant, there is the British Building, a structure designed in the Tudor style, and surmounted by a tin-crowned tower, an especially striking example of national architecture, and adjoining it, the Russian Building, the exact replica of the famous Moscow Kreml.

Opposite this Palace of Nations, there is the School Pavilion, comprising a hall for demonstrations and exhibits relating to the Boy and Girl Scout movement. In this pavilion is shown what a valuable help the book trade and graphic arts, in conjunction with the highly developed industry of educational appliances, are lending to the schools. An extensive group of buildings a little farther to the right then catches our eye. This is known as the "Industrial Town," and affords a fascinating picture of life and activity. The old Haynsburg Paper Mill here turns its wheels as 200 years ago, manufacturing hand-made paper in accordance with the methods of the time. A historical hand-printing plant is also installed where the type is cast and composed by hand. Side by side with these old, primitive shops are exhibited examples of the most advanced modern art, including a modern paper machine, which has a capacity equal to that of 500 hand-workers. In large halls housing the exhibits of the Association of German Paper Makers, visitors are shown the raw materials employed in paper manufacture, how these are worked into the various kinds of paper, and how manifold objects are manufactured from this material. This group of buildings terminates at the Newspaper Printing Office, where two huge rotary machines serve to demonstrate modern newspaper printing, while a third one illustrates in a most striking manner the most recent engraving process, rotogravure. The genesis of a newspaper is illustrated from the reporter's manuscript to the printed and folded copies. The historical development of journalism is also set forth, from the most primitive beginnings—fire signals and mounted messengers—up to the splendid achievements of modern engineering, wireless telegraphy, and telephotography.

On the left we reach a spacious pavilion housing a special show, "Woman in the Book Trade and Graphic Arts," where a comprehensive idea can be gained of the work done by women in all branches of printing, literature, music, the decorative art, library management, etc. Opposite this rises the hall where the Exposition of Trade Journalism and the special show of Stenography are installed. The latter demonstrates the whole evolution of shorthand from antiquity to the present day, with its manifold systems, and affords a practically complete picture of the highly developed shorthand industry.

Close to the other side of the main entrance, there are three auditoriums, holding 300, 600, and 1,200 people, respectively, and the moving-picture theater of the exposition. This part of the exposition grounds also comprises a number of cafés, restaurants, and places of amusement. Beyond the bridge there is a miniature German college town or *quartier latin*, illustrating the typical life of German undergraduates.

Light Alloys for Automobile Parts

Not many years ago one of the troubles of the manager of a big engineering works was the importunity of the purveyors of perfect lubricants. Though we still have these with us, the oil merchant has a serious rival in the man who claims to have invented a perfect aluminium alloy. Of these alloys there are some hundreds known by name, if not as a result of actual experience, and this number is being added to almost in inverse ratio as the cost of aluminium, owing to improved electrical methods, is reduced. Practically speaking, very few of the light aluminium alloys that have been produced with a view to revolutionizing engineering constructional methods have been a success from the industrial standpoint. The reason for this, as has been pointed out by Law, is to be found in the fact that aluminium unites with most of the common metals to form definite chemical compounds which crystallize out in a matrix of practically pure aluminium, and it is known that alloys with conglomerate structures of this description are only useful in special cases. Such compounds are formed with iron and copper, nickel, antimony, manganese, and tin.

ALLOY FOR MOTORCAR PARTS.

Zinc, on the other hand, forms what are known as solid solutions with aluminium, and the alloys of these metals, either alone, or more often with small additions of other metals, such as copper or magnesium, are practically the only ones of industrial importance. Alloys of aluminium and zinc have been very fully studied by various investigators, and are largely used in the motor industry for castings of crank-cases, gear-boxes, etc., the proportion of aluminium being, approximately, 88 per cent, that of zinc 10 per cent, the balance being made up of copper. Such an alloy has a tensile strength of from eight to ten tons per square inch. Though this particular alloy is stable, many aluminium-zinc alloys are liable to failure through aging, a process which can be prevented, however, by the addition of certain elements, which in many cases are claimed to give alloys very remarkable properties. What these elements are is not always perfectly clear, for though inventors often take the trouble to patent certain mixtures, and thereby tell the world what metals are supposed to enter into their alloys, it does not necessarily follow that all these metals are invariably used, or if used will be found to be present in the alloys on analysis.

Among the metals that are frequently added in small quantities to aluminium to produce special alloys may be mentioned nickel, manganese, silicon, iron, sodium, potassium, chromium, tungsten, titanium, mercury, and magnesium. The latter element was alloyed with aluminium the first time nearly forty years ago, and forms the basis of the well-known alloy, magnalium, which, unlike unsuccessful early magnesium alloys that contained as much as 10 per cent of the metal magnesium, now contains only something in the order of 1.6 per cent of magnesium, the resulting alloy being a much superior product, particularly when alloyed with about 1 per cent each of copper and nickel.

AN ALUMINIUM ENGINE.

In fact, it has been suggested in a paper read before the American Society of Automobile Engineers that the use of magnalium for the cylinders and pistons of internal combustion engines is a practical possibility, and here we may remark that we know of the existence in London of a small working internal combustion engine that is made entirely of alloy aluminium with the exception of the crankshaft and the flywheel. Besides the aluminium-manganese and aluminium-zinc alloys, there are many other binary alloys, including the aluminium-copper series and the aluminium-nickel series, but at the present time the tendency is undoubtedly toward the to be evolved more complex alloys made up primarily of aluminium, often as much as 95 per cent of this element being present, the remaining 5 per cent containing small percentages of several metals. There is no doubt that this is a step in the right direction, though obviously an enormous amount of experimenting has to be done—particularly when one is dealing with, as is often the case, four or five metals in addition to aluminium—to determine the best possible mixture to give the required results, and in this connection there may be mentioned a new complex alloy known as miralite, which appears to be suitable for many kinds of engineering work.

WIRE DRAWING.

This alloy, which consists mainly of aluminium and nickel in proportions, respectively, of 95 per cent and 4 per cent, with the addition of certain other rarer elements, has proved to possess excellent casting properties and to be suitable for rolling and spinning, and even for drawing into very fine wire. As showing its non-corrosive and untarnishable qualities, a large sheet of the alloy was towed behind a steamship to New Zealand and back, and proved on examination after six months' submersion in the sea to be as clean in appearance as when new. It appears to resist the action of all acids, with the exception of hydrochloric, which no aluminium alloy that has ever been made, or in all scientific probability ever can be made, will withstand. The alloy, it is claimed, does not disintegrate even after considerable friction and shock, as is proved by the fact that a complete railway carriage equipped with alloy furniture and fittings, after more than twelve months' continual use, and notwithstanding great vibration, is still perfect in every particular. The tensile strength of a sample of the alloy has been shown to be 12 to 14 tons to the square inch, or 17 tons in 18-gage wire. Its specific gravity is 2.62, which compares with 2.56 for cast aluminium and 8.6 for cast copper, so that it would appear to be nearly equal to aluminium in this respect, while much lighter than brass or German silver.

At present approximately 15 per cent of the aluminium output of the world is used for electrical purposes, and 65 per cent is used in the motor industry, leaving only 20 per cent for other purposes. It should be quite possible for the proportion as regards other purposes to be considerably increased now that what appear to be generally satisfactory, though complex, alloys are being produced which have almost unlimited applications.—*The Daily Telegraph* (London).

Some Characteristics of Antivivisection Literature*

Who are the Authors Quoted as Authorities by Antivivisectionists?

By Walter B. Cannon, A.M., M.D.

Some time ago I obtained from the four chief antivivisection societies of the country[1] copies of the pamphlets and leaflets which they distribute widely to school teachers and clergymen and other influential but medically uninstructed persons. For about two years I have also collected letters and articles which have been published on the subject in the daily press and in magazines. This literature can be considered with reference either to the justice of its claims, or to the fairness of its methods. For the present I wish to hold a consideration of the merits of the controversy in a secondary position and to examine these accumulated writings as to some of the tactics which they display.

To go through this matter with patience is a difficult task. Dreary iteration of the same opinions, the same "eminent authorities," the same tales, characterizes the society publications; and these publications, sent broadcast, are used again and again for texts, examples and references by contributors to newspapers and journals. Surely this is vain repetition, for any one whose intelligence is not stupefied with weariness can perceive that if the identical names and phrases and the identical instances have to be continuously cited, the cause must be short of both men and ammunition.

One of the most impressive exhibits which the antivivisectionists make is the list of physicians whose opinions they quote. This list is worth examining with some care. In doing so we should keep in mind that the great victories of experimental medicine have come since 1850, and in largest number since 1880; and furthermore, that this illustrious period of medical history is practically coincident with the use of anesthesia, not only in surgery, but in experimentation as well.

Many of the physicians whose opinions are quoted are dead. Some died long ago, others who have passed away more recently received their formal education in medicine before the period I have just mentioned. Of all the names cited the most renowned is that of Sir Charles Bell, born in 1774 and dead some 70 years, known for his discovery of the distinct functions of the dorsal and ventral roots of spinal nerves, and for his study of the functions of the fifth and seventh cranial nerves. In each of these important investigations his final proof was secured through experiments on animals. His own description of his greatest discovery is as follows: "On laying bare the roots of spinal nerves I found that I could cut across the posterior fasciculus of a nerve which took its origin from the posterior portion of the spinal marrow without convulsing the muscles of the back, but that, on touching the anterior fasciculus with the point of a knife, the muscles of the back were immediately convulsed."[2] On this experiment, done a hundred years ago, nearly forty years before the use of general anesthesia, his fame rests. To quote him to-day as opposed to the use of the experimental method is, under the circumstances, not only a contradiction of his own practice, but a gross anachronism.

Another name which, like the words of Humpty Dumpty, ought to be paid extra because so much overworked, is that of Henry J. Bigelow. He was born 92 years ago, and has been dead for 23 years. The address so often quoted was delivered in 1871—back four decades. According to the testimony of his colleagues in the Harvard Medical School, his views on vivisection were apparently based on what he had seen at the veterinary school at Alfort, France, in the pre-anesthesia days, and he had not controlled these early impressions by any experience in a modern laboratory. A close associate has testified that during the last years of Dr. Bigelow's life he never heard him say a word against animal experimentation.[3] Furthermore, in a letter which has been little noticed Dr. Bigelow objected sharply to the lack of discrimination among antivivisectionists. "The confounding of a painful vivisection," he wrote, "and an experiment which does not cause pain, either because the animal is under ether, or because the experiment itself is painless, like those pertaining to the action of most drugs, or because it is a trivial one and gives little suffering, has done great damage to the cause of humanity.'[4] And yet Dr. Bigelow is continually cited as a famous surgeon who was opposed to experiments on animals.

One other medical name appearing again and again in antivivisection writings is Lawson Tait (born 1845, died 1899). He has been described by a competent and trustworthy surgeon as a "man of wild statements."[5] Certainly that characterization is justified by Tait's promise that if he could get enough disease germs he would gladly use them as dressings for surgical wounds, and also by his absurd denunciation of Koch, Pasteur and Lister, the leaders of modern medicine, as men who had "not only hindered true progress, but covered the profession with ridicule." This extraordinary attitude, together with his opposition to the use of animals for medical research, is perhaps explained by a line in the sketch of his life: "He enjoyed being in a minority, and this led him to champion many lost causes."[6]

Other physicians whose opinions are quoted are of less note. There is Dr. Charles Clay, born in 1801, "interested in geology and archeology and collector of fossils." There is Dr. Charles Spooner, born in 1806, veterinary surgeon. There is Dr. John Elliotson, born in 1791, who alarmed his colleagues by administering extravagantly large doses of supposedly poisonous medicines; also mesmerist, and founder of a mesmeric hospital. There is Dr. J. E. Garretson born 86 years ago, and Dr. Elizabeth Blackwell, born 93 years ago. There is Sir William Fergusson, M.D., born more than a century since, said to be ill-advised in some expressions of opinion, "especially in matters requiring more knowledge of physiology and hygiene than he possessed." There is Charles Bell-Taylor (died in 1909, aged 80), who originated the widely quoted sentence, "Pasteur does not cure hydrophobia, he gives it;" and who, ignoring our great debt to animals for the medicines that induce sleep, for all those that give us local freedom from pain, for physostigmin, amyl nitrite, epinephrin, and many others, told his antivivisection admirers that experiments on animals have yielded us no knowledge of drugs. There is Sir Richard Owen, M.D., comparative anatomist and zoologist, born in 1804. There is Dr. John Abernethy, who died in 1831. There is Dr. J. J. Garth Wilkinson, born a century past, holder of an honorary M.D. degree, poet, mystic, expositor and editor of Swedenborg, author of "Improvisations of the Spirit," "Isis and Osiris in the Book of Respiration."[7]

In antivivisection literature the opinions of these persons are presented with no reference to the time when they were living and with no indication of the interests other than medical which filled their lives. The ingenuous reader takes his cue from the words of the pamphlet that they are "men of the greatest eminence among the vast number of physicians and surgeons who have opposed vivisection," and wonders how doctors can so profoundly disagree.

Among the living medical men quoted by the antivivisectionists, Sir Frederick Treves is most prominent. In 1898, he stated incidentally that some experiments which he had performed on the intestine of the dog had done little but unfit him to deal with the human intestine. This was, of course, merely his personal experience, and can readily be offset by that of other experienced surgeons who testify to the exact opposite. Indeed, there is probably no field of surgical manipulation that has benefited more by animal experiments than that of the gastro-intestinal tract. Sir Frederick was quick to point out the false implication placed on his remarks.

"Those who are familiar with the controversial methods of the antivivisection party," he wrote, "will not be surprised that certain of my remarks have been cunningly isolated from the context, and have been used in advertisements, pamphlets, and speeches, to condemn all vivisection experiments as useless. The fallacy of vivisection can hardly be said to be established by the failure of a solitary series of operations dealing with one small branch of practical surgery. No one is more keenly aware than I am of the great benefits conferred on suffering humanity by certain researches carried out by means of vivisection."[8]

That was written more than eleven years ago, yet Treves still continues to be quoted as another of the eminent surgeons who have opposed vivisection.

What I have been able to learn about the other living "physicians and surgeons of greatest eminence," quoted as hostile to experiments on animals, has come mainly from the publication, "Who's Who." Since the notices in this volume are little autobiographies, I should not be accused of employing the last resort of a losing advocate, the abuse of the opposing counsel, if I quote what these persons say about themselves. Dr. Arabella Kenealy sets herself down as novelist and contributor to magazines, author of "Molly and Her Man of War," "Some Men are Such Gentlemen," and other volumes. Dr. W. Gordon-Stables describes himself as novelist, journalist, professional writer for 24 years, author of 130 books with serial novels; "In the Dashing Days of Old" and "The Pirates' Gold" are cited as examples. Dr. W. R. Hadwen, secretary of the British Union for the Abolition of Vivisection, public advocate of the repeal of the Vaccination Acts and the prohibition of experiments on animals, is engaged in reform movements relating to temperance, food, hygiene, sanitation, education, and burial laws; he finds his recreation in changing his occupation. Dr. Edward Berdoe, born 77 years ago, reports himself as a writer; author of Browning studies, "Browning and the Christian Faith," "A Browning Primer," "The Browning Encyclopedia," "The Biographical and Historical Notes to Browning's Complete Works," and several other books; also editor of the "Zoophilist." Dr. Josiah Oldfield, a lawyer, and senior physician to the Lady Margaret Fruitarian Hospital, strong advocate of the fruitarian diet; author of "Flesh Eating as a Cause of Consumption," "Butchery and Its Horrors," and other volumes. Dr. J. D. Buck, 7 years old, president of the Theosophical Society of

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* Pamphlet xix, issued by the Council on Defense of Medical Research of the American Medical Association, republished by permission of the Association.

[1] The New England (Boston), the New York (New York city), the American (Philadelphia), and the Vivisection Reform Society (Chicago).

[2] A New Idea of the Anatomy of the Brain, London, 1811.

[3] Animal Experimentation, Boston, 1902, pp. 48, 74.

[4] Anesthesia: Addresses and Other Papers, Boston, 1900, p. 371.

[5] Animal Experimentation, Boston, 1900, p. 47.

[6] Dictionary of National Biography.

[7] The data given above were found in the Dictionary of National Biography.

[8] *The Times*, London, April 18th, 1902.

Ohio, author of "Nature and Aims of Theosophy," "Mystic Masonry," "Why I Am a Theosophist." Dr. Stephen Townsend, novelist, surgeon, and actor, on the stage for years, playing prominent rôles in "Sowing the Wind," "Slaves of the Ring," "Black Tulip," and others. This completes the list of "eminent" physicians and surgeons who have opposed vivisection, concerning whom I have been able to find any characterization whatever, the rest are not of sufficient importance to be mentioned in any of the dictionaries or cyclopedias of biography that I have searched through for information. And this is the array of medical experts who have denounced the method of investigation which, according to Osler, "did more in the half-century between 1850 and 1900, to emancipate medicine from the routine and thraldom of authority than all the work of all the physicians from the days of Hippocrates to Jenner."

I do not wish to imply that unless a physician does nothing but practise medicine his opinions on medical matters are of little value. But when a person with a medical degree denounces the antitoxin treatment of diphtheria, I am interested to learn that the time of that person is spent in composing romances. When another declares that the cruelty of experimentalism is "horrible to contemplate," I am better able to value his words when I know that instead of "contemplating," he has for 24 years been industriously writing and has now to his credit nearly seven-score volumes. A third expert who declares experiments on animals useless and unscientific, I understand better when I find that he is a professional agitator, working for the abolition of vivisection and for the destruction of community barriers against small-pox. The sounding phrases, "Pasteurian quackery," "antitoxin nostrum," "vivisection founded on cruelty, supported by falsehood, and practised for selfish ends," have less significance when I realize that they are the expression of an aged man who has devoted his life to studying, annotating, and editing Browning's poetry. Again, in reading the grotesque exuberance of the fruitarian lawyer, that "vivisection takes no note of pain; its spirit is not healing, but killing; its object is not to relieve pain in the victim, but to cause it"—I wonder in precisely what way fruitarianism and the law have given him intimate acquaintance with the subject he so roundly denounces. And finally, when the theosophic propagandist, past his threescore years and ten, unites with the actor-novelist-playwright in declaring that "scientifically" experiments on animals are useless, I have a basis for seriously suspecting that they are not trained to judge these matters scientifically.

If now we examine this list, we find that it is made up of persons long-since quick, or long-since dead, persons who have not been opposed to vivisection in any unqualified sense, persons whose eminence in literature and art was the only eminence they possessed, and persons so obscure as not to be noticed in any manner whatever, except in the pages of an antivivisection leaflet. When we consider that every advance in medicine, like every advance in other realms, has suddenly revealed the reactionaries, the great marvel is that there are not medical men of real prominence who will support the antivivisection cause. But if "among the vast number of physicians and surgeons who have opposed vivisection," those we have just investigated are "of greatest eminence," surely the professional endorsement is insignificant.

Demonstration that many of their experts have no respectable qualifications for testifying will not, I believe, cause the antivivisectionists to withdraw either the names or the opinions of these men from circulation. Sir Frederick Treves called attention to their adroit misuse of his remarks more than eleven years ago. Instead of respecting his expression of direct disapproval of their cause they have continued classifying him as an opponent of vivisection. The ignoring of Treves's correction is a thoroughly characteristic maneuver on the part of the agitators. Other examples are numerous. Commenting on an experiment by Dr. H. P. Bowditch, in which the peripheral end of a nerve, which had been severed under ether, was stimulated, Mr. P. C. Peabody stated: "It will be readily seen, even by the casual reader, that it involves an amount of agony beyond which science is unable to go and to approximate to which is impossible except by a person who has devoted long years to the study of nerves." Eighteen years have passed since Dr. Bowditch plainly pointed out the utter absurdity of the assumption that even the slightest pain could have been inflicted by stimulating a piece of nerve separated from the central nervous system,[9] and yet the New England Antivivisection Society was recently still distributing this ancient slander.

Thirteen years ago Dr. W. W. Keen,[10] in a paper of admirable simplicity and directness, laid bare instances of repeated interpolations, mistranslations, and garbled, inaccurate accounts of experiments in a single antivivisection publication. What was the effect? To what degree have 13 years been sufficient for the development, in antivivisectionists, of respect for the facts?

In a pamphlet now being circulated I find mentioned Dr. Berkley's observations on the effects of administering thyroid extract to insane patients. Although Dr. Keen showed that the therapeutic use of thyroid extract varies between 15 and 60 grains per diem, and that Dr. Berkley's maximum dose was only 15 grains per diem, the pamphlet does not distinguish between the toxic effects of these small doses in some cases and the beneficial effect in others, but declares that Dr. Berkley was "poisoning" his patients. It goes on to state: "Two patients became frenzied, and of these one died before the excitement had subsided." In the original the sentence is completed by the words, "the immediate cause of the exitus being an acute disseminated tuberculosis." The absurdity of attributing death by galloping consumption to thyroid tablets, which had not been given anyhow for seven weeks, was clearly explained by Dr. Keen more than a decade ago. He did not emphasize the wrong done to Dr. Berkley by the crafty mutilation of a sentence. Of course, a decent sense of honor would have impelled an instant correction of this wrong, yet the antivivisectionists have continued these 13 years to deceive the credulous public without any moving consideration that their imposture involved a man's good name.

Another statement in the pamphlet is as follows: "Dr. A. H. Wentworth, senior assistant physician to 'The Infants' Hospital,' Boston, made forty-five vivisections, tapping the spinal canals of children, many of whom died." Unless the writer of this statement intended to intimate that there was a connection between the death of the children and the tapping of the spinal canal, the statement is without significance in an antivivisection publication. A careful reading of Dr. Wentworth's paper shows that the tapping of the canal, which is now (though it was not then) a common routine procedure, had no harmful effects whatever. To be sure, *some* of the children died later, but in every fatal instance the cause of death, which had no relation to the operation, was definitely determined and stated. All these facts Dr. Keen pointed out 13 years ago. What was the result? The story with its evil insinuation is still circulated everywhere by the antivivisectionists, again without any observable respect for the facts, or regard for an honorable reputation. Even this exhibition of hostility has not proved a sufficient outlet for antivivisection feeling, for in the *Journal of Zoophily*, April, 1910, p. 44, Dr. Wentworth is referred to as having experimented "on between forty and fifty little children in the 'Children's Hospital' of that city (Boston) *every one of whom* died after the performance of his operation."

Six years have passed since the attention of officers of the New York Antivivisection Society was called to the fact that by suppressing mention of anesthetics in experiments they described, they were giving a wholly false impression of the way in which these experiments were conducted. Again, several years ago, Dr. F. S. Lee indicated in a public letter[11] that the society, in spite of having had a full year in which to correct these misrepresentations, was intent on its policy of deluding the public. I have recently had occasion to examine again the pamphlets which the society is distributing; the misrepresentations were still there, unchanged.[12] Details of operations by Dr. W. S. Halsted are quoted, and although the original account expressly stated that anesthetics were employed, the pamphlet does not even suggest them. Selections taken here and there from Dr. G. W. Crile's report of his experiments on surgical shock are presented, again with no intimation of anesthesia; and this in spite of Dr. Crile's printed statement that "in all cases the animals were anesthetized," and also in spite of the testimony of Dr. F. W. Goodbody[13] and of Sir Victor Horsley[14] (in whose laboratory, under the English antivivisection law, much of the work was done) that the animals, though sometimes exhibiting reflexes, were completely insensible to pain.

The society furthermore continues to suggest that one can only imagine "how intense the suffering," which caused a cat at the Rockefeller Institute to "spend the day jumping on and off the furniture," when in fact, as Dr. Carrel explained 5 years ago, the animal was a young cat, in perfectly normal health, manifesting its natural playfulness.

From these specimens of persistent disregard of fair treatment, when can we expect that mis-statements and evasions, even if publicly exposed, will be withdrawn? Two years are evidently not enough for the antivivisectionists to manifest this sense of honor, nor are ten years, nor fifteen. I have cited instances in their literature, instances of grossly garbled descriptions of the work of medical men, the inaccuracies in which have been clearly demonstrated for these long intervals, without, however, any sign of a tendency on the part of the prevaricators to reconstruct their statements in conformity with the facts. Experience has proved that the false story once well told, need not be withdrawn or altered, even if its falsity has been exposed, for that part of the public that likes to be humbugged is ready to read and listen and yield its humble credence.

The fundamental wrong committed by the antivivisectionists in their agitation against medical research is the presentation of a misleading issue. They deny that any utility has come from animal experimentation, they describe the experiments as horrible torturing of dumb brutes, and then they ask if this futile cruelty shall be permitted to go on. If this really were the whole story, few would hesitate on which side to stand. Every decent man and woman is opposed to cruelty; every decent human being winces at the thought of inflicted pain. It is for this reason that the picture of the fastened dog makes such a powerful appeal. But this is not the whole story. As I have pointed out elsewhere, it would be as fair to display a picture of Grenfell fighting his faithful dogs and stabbing them to death, labeled "is this the way to treat your pets?" as it is to represent animal experimentation without its motives and without its triumphs. Grenfell, in his struggle on the ice-pan, stabbed his dogs[15] to save his own life, and every man with common sense commends the bravery, the resourcefulness and the proper sense of values of this missionary hero. That is what any worthy man who sees straight would try to do if he were cornered and had to spend his own life or that of lower animals. Precisely that is the issue which the investigators see. And they know also that by the sacrifice of some animals the chance of life and health for mankind and for myriads of other animals as well, has been enormously enlarged. Read the articles, written recently by experts in the several fields, telling the relation of animal experimentation to the treatment of diphtheria and tetanus, to meningitis, rabies, small-pox, to dysentery and cholera and typhoid fever, to plagues, tuberculosis, syphilis, to the disturbances of internal secretions, to our knowledge of the action of drugs, to surgical technic, to childbirth, to hygiene and preventive medicine—read these articles[16] and learn what the animals have done for their fellow creatures. Just because they have rendered such immeasurable service do we turn to them for further aid. Of the animal thus used Prof. William James has written with illuminating insight: "If his poor, benighted mind could only be made to catch a glimpse of the human intentions, all that is heroic in him would religiously acquiesce."[17]

Before the antivivisectionists can command the respectful attention of intelligent people they must fundamentally change their tactics. They must clear their literature of the anachronistic hostility of men long since dead, men who had no conception of the merciful procedures of modern experimentation, nor of its life-giving results. They must rid their publications of the testimony of spurious experts whose reputations were made in literature, art or theology, and not in the service of healing. They must purge their propaganda of the fraud and trickery and evil insinuation that have for years characterized it. And I may perhaps be permitted to suggest that the process of making their methods clean and their ways straight involves paying some respect to the high purpose of biologic investigation and its beneficent achievements for human welfare, which together give meaning and sanction to the experimental use of animals.

The Explosion of a Balloon.—The explosion of a spherical balloon is an accident which is fortunately of rare occurrence. Much damage was caused by the explosion of the balloon belonging to the well-known aeronaut Leprince at Epernay, France. Starting on a flight at 5 o'clock P. M., from a public square, a gust of wind drove it against a tree, causing a rent in the balloon, and it then exploded, possibly from the presence of a smoker in the crowd. No less than 25 persons were wounded by the explosion, including the aeronaut, he no doubt fatally.

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[9] Communications of the Massachusetts Medical Society, 1896, p. 43.

[10] The *Journal A. M. A.*, February 23rd, 1901.

[11] New York *Evening Sun*, March 12th, 1909.

[12] These publications, which contain also the statements about Dr. Wentworth and Dr. Barkley above mentioned, were sent to a friend of mine in November, 1910, with a letter from the president of the New York Antivivisection Society proclaiming, with reference to the pamphlets: "You may rely on them as being absolutely accurate and authentic."

[13] London *Times*, March 13th, 1902.

[14] Minutes of Evidence, English Royal Commission on Vivisection, 1906-08, Questions 15893-7, 16220-2.

[15] Grenfell, Wilfred T.: A Voyage on a Pan of Ice, Boston, 1908.

[16] Published by the American Medical Association, Chicago.

[17] The Will to Believe and Other Essays, New York, 1899, p. 58.

Controlling Ships' Engines Directly from the Bridge

Mechanism Which Places the Control into the Captain's Hand

No point the greatest divergence from accepted marine standard and practice in the original installation in the "Neptune,"[1] was in the method of control of the turbines, they being under the control of the navigator on the bridge, as well as from the starting platform. To marine engineers and navigators, such an innovation probably appeared unnecessary and fantastic, and too great a step aside from the trodden path to be safely employed; and that such feeling existed, and probably still exists in the minds of some engineers, is shown by the hostile criticism of the bridge control.

However, after the trials of the "Neptune" and months of service, the bridge control has shown itself to be absolutely reliable, and after becoming accustomed to it, those having experience with it have come to use it in preference to the ordinary engine room telegraph which was, of course, a part of the "Neptune's" equipment.

During the service of the "Neptune," a number of occasions arose in which the advantages of the bridge control were shown in a very striking manner. This is brought out in the report of Lieut. W. W. Smith, U. S. N., who was in charge of the "Neptune's" machinery, and from which we quote as follows:

"The bridge station has been used in steaming, in going alongside ships, and in docking. While steaming it requires practically no attention, as the regulation is automatic. The speed has been regulated accurately, but not as accurately as desired. Unfortunately there has been no opportunity for steaming in formation, but I have no doubt of the suitability of the control system for this purpose. In maneuvering, in coming to anchor, going alongside, etc., the regular bridge detail has handled the turbines without difficulty. In this connection, attention is invited to the fact that none of the deck officers are experienced in engineering. In fact, they have no knowledge of it. If men of this type can use the bridge control, there should be no difficulty on a naval vessel. In maneuvering, the control gear has operated satisfactorily. The indicators show the operator what the turbines are set to do, and what they are doing. Gages show the air and steam pressure available. The gages and indicators have special dials so that the indications can be understood by an untrained man. With this control gear, it is as easy for one man to operate the engines of a battleship as it is to run an automobile.

"Under service conditions, there is a saving in time in operating from the bridge of from 2 to 6 seconds, which depends principally on the engine-room operator. Under test conditions, of course, this would be less. To the officer on the bridge, it gives confidence to know that the propellers are entirely under his control, that the control gear operates quickly and exactly the same each time. There is no doubt as to whether the signal is being answered properly and promptly. There is no one over whom he has no control to use discretion to keep the steam up when the ship is in a dangerous position. In case of emergency, the officer on the bridge can best decide whether it is best to save steam or avert a collision.

"In two instances it was necessary to increase the speed suddenly to avoid collision. The steam pressure dropped very low and some of the auxiliaries were about to stop. The engineer protested vigorously against such unwise operation. He, not knowing the danger, would probably have eased up to save steam, and collision would have resulted.

"During one voyage the propellers came out of water so that excessive racing would have occurred with ordinary machinery. Most of the time they came half way out, and frequently they came practically all the way out. Owing to the action of the governing mechanism, racing was prevented. The speed increased and decreased slightly—about 4 per cent estimated. The turbine inlet valves were opening and closing continuously, and at times they were entirely closed. Quick-operating valves are necessary to effectively prevent racing. This feature of the control system is of importance because it will enable a vessel to steam at considerable speed in heavy weather.

"After being modified, the control system has been thoroughly reliable. Even if the bridge control should fail, it only requires a few seconds to change to the engine room. This feature has been frequently tested and found satisfactory. However, with the improvements which will be made in accordance with the experience gained with this, the first installation, I am convinced that operation from the bridge will be absolutely positive and reliable under all conditions. In my opinion, it will be more reliable than the telegraph, although the latter is good in this respect. As the general principles are the same, there is no reason why it should not be as reliable as the air brake, or even more so, as the service is less severe."

The medium used for transmitting to the engine room the movements of the control handle on the bridge, is air, and the actual operation of the relays moving the steam valve, is effected by oil.

A diagrammatic arrangement of the operating parts of the control system, including the bridge valve and steam nozzle valves, is shown in Fig. 1. As will be seen from examining the left-hand part of the illustration, the bridge control lever D' is movable in two quadrants A' and C' with an offset B' parallel to the axis of movement.

When the control lever D' is at B' both the ahead and astern nozzles are closed. The operating handle D' turns a shaft carrying a cam E'' which has pressed against it the point of a small valve F''. The valve F'' is hollow and closed at both ends, and has two sets of ports, G' and H', the former always being in communication with the source of high pressure air supply (furnished by a standard Westinghouse air brake compressor), and the latter having its edge to the extreme left, just line in line with the ports I' in the piston L'. The end of the plunger valve F'' is line in line with left-hand edge of the ports I'. A small spring K' within the piston L' is provided to maintain a positive contact between the point of the plunger F'' and the cam E'', thus fixing the position of the plunger F'' by its point of contact with the cam E''. The movement of the piston L' to the left is resisted by the spring N'. The space J' to the right of the piston L' communicates with space Q' between two diaphragms R' R' and the space to the left of the piston L' communicates with the atmosphere. A communication to the passage within the piston L' to atmosphere is provided by the ports M'.

Bridge control stand.

The diaphragms R' R' control two valves T'' and U'', the former controlling an opening to atmosphere, and the latter an opening to the source of high pressure air supply. The spaces S' S' are connected by a passage, so that the pressure in them is always equal. The space S' communicates either with the ahead or the astern operating relay in the engine room.

The function of the bridge control valve just described is simply to maintain a predetermined constant pressure in the air relay chamber, and this is accomplished as follows, with the apparatus just described.

When the lever D' is moved from its central position, B' to the ahead quadrant A', the cam E'' pushes the valve F'' to the left, thereby bringing the port H' into communication with the port I' in the piston L'. This admits high pressure air into the space J', and consequently Q'. As the pressure in the space J' increases, it will quickly force the piston L' to the left, until the right hand edge of the port I' cuts off communication with the port H', or should there be leakage, it will take a position such that the opening through the ports H' and I' would be just large enough to pass sufficient air to make up for the leakage and maintain a constant pressure in the space J'.

Since normally the spaces S' S' are at atmospheric pressure, when the pressure between them in the space Q' is increased, the diaphragms are forced outward, closing the valve T'' and opening the valve U'', thus admitting high pressure into the space S' S' until the pressure in the latter is equalized with the pressure in the space Q', thus bringing the diaphragms back to their normal position, permitting the valve U'' to seat and thus cut off the supply of high pressure air. The pressure existing in the space S' is transmitted to the space P^1 to the left of the air relay chamber in the engine room.

As in the case with the piston L' and the ports I' and H', should there be leakage in the piping system communicating with the space S', the diaphragms R' R' will be distended slightly, thus holding the valve U'' open sufficiently to make up the leakage and maintain constant pressure. Conversely, it is evident that if the pressure in the space J' should increase above that predetermined for a given position of the piston F'', the piston L' will move to the left, and open communication between the space J' and the inside of the piston L', thus exhausting air from the space J' to atmosphere through the port M'. This condition also arises when operating lever D' is moved toward the off or central position, which permits the movement of the valve F'' to the right. In the latter case the pressure in the space Q' will be decreased and become less than the pressure in the spaces S' S', causing the diaphragms R' R' to collapse and open the valve T'' to atmosphere until the pressure in the spaces S' S' is decreased to that in the space Q'.

When the control lever D' is to be moved to the astern position, it is necessary to move it in the direction of its axis of rotation in the slot B'. When this is done, and arm W'', held between two collars on the cam shaft, moves the small slide valve X' to the right, and brings the pipe Z' to the astern air relay cylinder into communication with space S', and the pipe Z'' into communication with the atmospheric exhaust.

From the above it will be seen that it is impossible for the operator to become confused and accidentally move the control lever in the wrong direction, or try to put it in both the ahead and astern position at the same time, as it is necessary to move the controlling lever sideways before it can be moved from one position to the other.

The governor, which controls the speed of rotation of the turbine shaft, is shown on the right of the diagrammatic sketch, Fig. 1. As will be seen, it is of the common fly-ball type, and is driven through the turbine shaft by a worm E and wheel D. The only movable part of the governor is the hollow spindle B, having the ports N and H in it. The movement of the spindle B is restricted by a diaphragm K to which it is attached. The upper side of the diaphragm is open to atmosphere, and the space below G is filled with oil.

High pressure oil at about 65 pounds gage per square inch is admitted to the revolving spindle B through the ports A.

When the governor spindle is revolved by the turbine shaft, the balls M M are thrown outward by centrifugal force, thus pulling the spindle B downward against the resistance of the diaphragm K, opening communication through the port H in the spindle, and I in the upper spindle bushing, to the space G, the latter communicating through a port L to a pipe connected to the space N of the air cylinder relay.

As the pressure in the space G, below the diaphragm K, increases, it resists the downward thrust of the spindle B, due to the centrifugal action on the governor weights until the upward pressure on the diaphragm exactly balances the downward thrust of the spindle, thus permitting the upward movement of the spindle B by the elasticity of the diaphragm K until the communication through the ports H and I is cut off. Thus it is evident that for any given number of revolutions of the governor spindle, there must be a constant fixed pressure of equilibrium in the space G below the diaphragm. Should the pressure in the space G exceed that corresponding to the speed of rotation of the governor at any instant, the spindle B will be forced up ward, thus opening communication between the space G and the atmosphere through the ports N in the governor spindle body.

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[1] For an account of the machinery of the "Neptune," see Scientific American Supplements, May 30th, 1914, page 348, and June 20th, 1914, page 392.

In the center part of the diagrammatic sketch is shown the air relay cylinder, relay valve, and operating cylinder, which controls the opening and closing of the nozzles of the turbine according to the speed of rotation desired. Referring to this part of the illustration, and starting with the turbine at rest, the piston Y, which opens and closes the nozzle valves, is at the farthest end of its travel to the right, and all the turbine nozzles are closed. Now when air from the bridge control valve is admitted to the space P, to the left of the air operating cylinder, the piston Q will be forced to the right against the resistance of a small spring, thus carrying the relay plunger O with it. The movement of the latter establishes communication between the space R, supplied with high pressure oil, and the space X, to the right of the piston Y, and the space W, to the left of the piston Y, is brought into communication with the space T, and thereby with the oil return to the reservoir, which is open to atmosphere. Thus the piston Y will be forced to the left by the oil pressure and through a rack engaging with the gear cut in the periphery of the nozzle valve, will rotate the latter and open high pressure nozzles, thus admitting steam to the turbine. As there is nothing to resist the motion of the piston Y, nozzles in excess of those necessary to give the desired speed are opened instantaneously, and thus the turbine begins to speed up very rapidly. Now, however, as the turbine gains speed and the governor revolves, the governor spindle B is forced down and high pressure oil is admitted through the ports H and I and through the passage L to the space N to the right of the piston Q, thus tending to push it to the left against the air pressure in the space P. As the piston Q moves to the left, it carries the relay plunger O with it, and when the oil pressure in the space N balances the air pressure in the space P, or in other words, the space J' in the bridge control valve, the piston Q will take a fixed position, and the piston Y will take up a position such that the ports communicating with W and X are both closed, thus maintaining a constant speed of revolution.

Should the turbine tend to exceed the speed fixed by the air pressure in the space P, the piston Q would move to the left and bring the space X into communication with the space S, connected to the oil exhaust, and the space W would be brought into communication with the space R, supplied with high pressure oil. This would cause the piston Y to move to the right until sufficient nozzles had been shut off to reduce the speed, until the oil pressure in the space N was again brought into equilibrium with the air pressure in the space P.

The bridge operating stand which supports the bridge control valves is shown in our half-tone engraving, from which it will be seen that there is a rotary slide valve on top of the stand between the port and starboard control valves. This latter valve is not shown in the diagrammatic sketch previously described, and is not shown in detail because of the difficulty of showing tho various ports in it. Its function, however, is to permit operating both turbines, either ahead or astern, by either the port or starboard control valve, or to cut out both the starboard and port control valves. In addition to these functions which this valve performs on the bridge control stand, tho similar valve on the control stand in the engine room has a position for cutting out the bridge stand and other operating stands in other portions of the ship; thus when the control system on the bridge is connected, all control stands excepting that in tho engine room, are made inactive, while if the stand in the engine room is being used, all other stands (including the one on the bridge) are disconnected. This arrangement avoids interference, permits rapid changes from one station to another, but always leaves the engine-room stand operative in case of an emergency.

Ordinarily, except when maneuvering, the bridge stand is always connected up so that both turbines are controlled by moving either the port or starboard control levers, which simplifies the operation and permits controlling both turbines if either the port or starboard operating valves should for any reason become temporarily disarranged.

In addition to the standard screw down valves on the ahead and astern turbines, each turbine is provided with a hand operating device, by means of which a nozzle valve can be moved by hand, if necessary or desirable.

This is accomplished by the lever h as shown in the diagrammatic sketch, Fig. 1. The lever is pivoted on the shaft j and has a lever engaging with the crosshead on the valve operating piston rod i. Tho latter lever is fitted with a latch so that it can be quickly connected or disconnected when not in use.

As previously pointed out, there may be a number of operating stations from which the turbines can be controlled when this is desirable, as for instance, there might be considerable advantage in the case of battleships in having the turbines controlled from the central station as well as from the bridge and starting platform.

After the officers have once become accustomed to using the bridge control, they will no longer use the engine room telegraph and will not feel as a man would, had he only the steering wheel of an automobile under his control and were he compelled to rely upon an engineer to control the speed and the direction of motion independently. As far as reliability is concerned, this has been absolutely proven by the experience on the "Neptune."

The only difference between the diagrammatic sketch and the actual valve gear is that in the latter the various parts have been placed one within the other in order to make the valve more compact.

In order that the officer on the bridge or navigator may be able to see that the turbines are operating as desired, and also to show that the control system is in operating condition, gages are provided which show the steam pressure in the boilers, the air pressure in the control system, the air pressure in the pipe lines $Z' Z''$ as well as the pressure in the oil supply system, and the pressure of the oil under the pistons of the floating frame on the reduction gears.

As it would be frequently necessary to havo the piping communicating from the engine room to the bridge in exposed places where it would be liable to freeze and because of the difficulty of allowing for the hydrostatic head in the pipe between the bridge and the engine room in the case of liquids, the steam and oil pressures are indicated on the bridge by means of compressed air and a small relay valve, such as illustrated in Fig. 2. As the steam pressure or oil pressure to be indicated on the bridge may exceed the air pressure available, the former are reduced in some ratio, such as 2 to 1 or 3 to 1, as required.

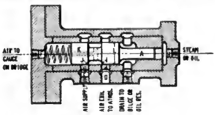

Fig. 2.

In Fig. 2 the orifice B is connected to the steam or oil line, and the pressure desired is indicated on the bridge by the air pressure in the pipe connection to F, which communicates with the gage on the bridge. The operating element of the relay consists of the plunger LA, having L and A the same diameter or A a smaller diameter than L for relaying oil or steam pressures. The plunger LA is fitted in a bushing, having ports G and H, port G communicating with tho high pressure air supply and port H communicating with atmosphere. A drain C is also provided, which may either drain to the bilge or to the oil reservoir when oil pressure is being relayed.

Normally, when not being used, the small spring pushes the plunger LA to the right, and the gage on the bridge is then connected to atmosphere through the ports K and H. When steam or oil under pressure is admitted at B, the plunger LA is forced to the left against the resistance of the spring, and the edge J of the plunger LA moves over the port G and admits high pressure air through the port K to the gage on the bridge, the pressure in the space to the left of the plunger LA increases until the pressure times the area of the left-hand portion of the plunger LA equals the pressure times the area on the right-hand portion of the plunger LA; thus if the diameter of the plunger L is twice the diameter A, the area of the large end of the plunger will be four times that of the small end, and the actual pressure maintained on the left-hand side of the plunger will be one fourth of that maintained on the right-hand side of the plunger; thus 200 pounds gage steam pressure would be indicated on the bridge by 50 pounds of air pressure. The oil pressures are transmitted to the bridge in the same way.

This relay device has been found very sensitive and accurate, and so far has never given any trouble in the installation on the "Neptune."

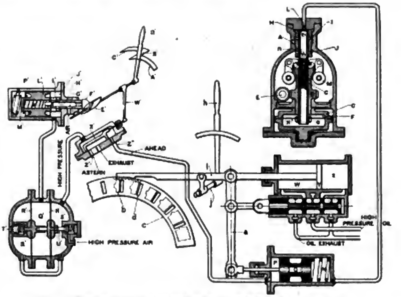

Fig. 1.—Diagrammatic arrangement of bridge control and nozzle valves.

There is a fixed pressure (for any given number of revolutions per minute of the turbine shaft) in the spaces Q' and $S' S'$ as well as under the diaphragm K in the governor spindle and the space N to the right of the air operating cylinder. Consequently, instead of graduating the gage recording the air pressure in the space S' in pounds, this scale may conveniently be graduated to read revolutions per minute, so that those in charge on the bridge can see every instant exactly the number of revolutions which the propellers are making.

Another novel feature of the new control apparatus used on the U. S. "Neptune" is a set of speed recording instruments. As previously mentioned, for any given turbine speed there will be a definite oil pressure under the diaphragm K of tho governor, and consequently this pressure can be used to indicate the speed of the turbine and propeller.

Pressure gages of the recording type may be used, showing the speed, direction of rotation, and period of operation of each turbine under any given conditions. These records furnish an accurate log which is indisputable in case of a controversy regarding the speed or manner in which the turbines were operated. These cards can be graduated to read revolutions or knots, as desired.

The Limit of Fatigue

Professional fatigue can be measured from the variations of the tracing or sketch of the movements of the heart. According to the experiments of M. Jules Amar explained by Prof. Dastre, it has been seen that as the power developed by the muscles increases, the form of the cardiograms is changed. Their summit becomes more and more pointed. The undulation on the right that is supplied by the contraction of the heart lowers progressively. After the contraction that drives back the blood an aspiration is produced, the value of which goes on increasing. In all physical work, carrying of burdens up staircases, fatiguing walking, running, work with the hammer, M. Amar has noticed curves that have an aspect identical to the physiological limit of fatigue.—*Chemical News.*

Transatlantic Flight*

A Discussion of Possible Routes

By Lieut. H. Boykow, Imperial German Navy, Retired

By the latest endurance records in aviation the project of a transatlantic flight has been removed from the domain of vague and distant hopes, and placed among the immediate possibilities. Routes are available for the undertaking, which, as to distance and time, appear to be no more formidable than those over which aircraft have already flown. If it happens that on these very routes—i. e., the shortest available—serious obstacles present themselves, these obstacles are not found in the length or probable duration of the journey, but in circumstances of greater weight, to which due regard must be had if a route is to be selected in accordance with the idea that navigation is the art of bringing a vessel to her destination over the best course. The best course is not the shortest, nor the most convenient, but that which a scrupulous regard for all factors points out as offering the greatest security, combined with the minimum distance consistent with such security. Thus, for example, the fast transatlantic steamers, in the operation of which time is certainly an important consideration, do not follow the shortest routes, because the navigation of such routes is hazardous, and would compromise the principal purpose of the journey, which is to get the vessel safely to her objective point. In a much higher degree do these considerations apply to aircraft, which, although the most modern method of transportation, hardly vie in safety even with the primitive vessels of the ancient seafaring races of mankind.

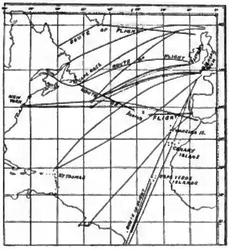

Chart 1.
International steam lanes, February 1st to August 31st.
———— English Channel—New York, westward.
………… English Channel—New York, eastward.

Two points must be taken into consideration before all others, viz., the normal and probable weather conditions along the proposed route, and the probability of being able to get help in case of an accident. These two points should be given the greatest weight in determining the route. In view of the fact that aircraft are still limited in their range of action, and also of the possible need of intervals of rest on the part of the aeronauts, a third consideration is the possibility of breaking the journey at suitable points.

We shall first discuss the normal weather conditions along the various routes. Broadly speaking, four routes are possible:

1. The northern, or Greenland, route, from Labrador *via* the southern point of Greenland to Iceland or the Hebrides. This route, especially if *via* Iceland, is the shortest. The distances are: Labrador to Greenland, 980 kilometers (609 miles); Cape Farewell to Iceland, 1,200 kilometers (746 miles); Cape Farewell to the Hebrides, 2,200 kilometers (1,367 miles). It should, however, be stated at once that the Iceland route is practically ruled out by the fact that a stationary area of low barometric pressure lying south of Iceland is almost certain to give winds from an easterly quadrant.[1] At best this could only be regarded as a possible route for a journey from east to west, but there are other grounds, to be mentioned later, which exclude it from consideration.

2. The direct, or steamship, route from Newfoundland to Ireland. The distance to be covered by this route is 3,100 kilometers (1,926 miles), or still greater if the regular international steam lanes are followed. Aside from its length this route offers great advantages.

3. The Azores route, from Newfoundland *via* the Azores to the coast of Portugal. The distances are 2,000 kilometers (1,243 miles) for the first stage, and 1,300 kilometers (808 miles) for the second. These distances have already been surpassed by aeroplanes.

4. The equatorial route, from the Cape Verde Islands to Fernando do Noronha, on the Brazilian coast. The distance amounts to only 2,500 kilometers (1,553 miles), but in other respects this route appears less promising.

Except as to the equatorial route, which is available in winter or early spring, only the summer months need be considered as appropriate for a flight, viz., June, July, and August. We will now briefly examine the meteorological features of the North Atlantic, especially along the proposed routes. The first six charts accompanying the article serve further to elucidate this matter.

JUNE.

The maximum (of barometric pressure) at the Azores and the minimum south of Iceland begin to be more sharply defined, and consequently west winds become more frequent and stronger between latitudes 40 and 60 degrees north. Over the western half of the ocean the winds are prevailing southwesterly. Along the principal steamer routes (i. e., between latitude 40 and 50) June is one of the calmest and driest months of the year, with prevailingly fair weather. Barometric depressions are commoner at this season on land than on the ocean. Only along the storm track from Newfoundland to Iceland are they frequent; between Labrador and Greenland, in particular, secondary minima as low as 720 millimeters (28.35 inches) are likely to occur. The latter may also be said of the southeastern border of the Newfoundland Banks. In general, however, June and July are freer from storms than any other months of the year. On the southeastern border of the Banks, where at all seasons winds reaching force 8 on the Beaufort scale are frequent, not more than 6½ per cent of gales have been recorded in June, while in January, for example, the gales attain 38 per cent. The region of greatest storm frequency is generally identical with the region of the Gulf Stream.

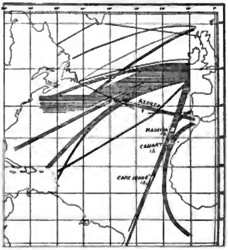

Chart 2.
Density of travel on the principal steam routes.

The frequency of fog has somewhat increased. On the Banks and the American coast there are areas having over 200 hours of fog in the month. South of latitude 40, however, the ocean is practically fog-free.

The average weather conditions on the several routes in June are as follows: On the Greenland route, over the westerly half of the stretch between Labrador and Greenland the prevailing winds are north and east, with force 3 to 4, freshening and shifting to northwest as one proceeds toward Greenland; but revolving storms, moving generally from the southwest, are still comparatively common in this month. Just west of Greenland fresh westerly to southerly winds prevail, though small barometric depressions may also occur here, moving in a direction between southeast and northeast. Winds of force 4 to 6 predominate, and calms are rare.

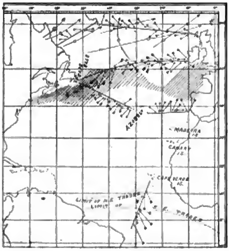

Chart 3.
Limits of trades in July.

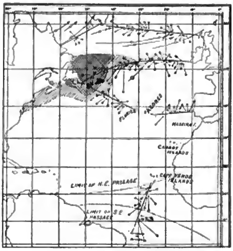

Chart 4.
Weather conditions in August.

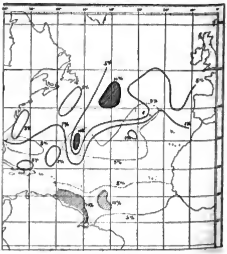

Chart 5.
Storms and calms in September.

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* Translated for the SCIENTIFIC AMERICAN from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*.

[1] This statement is hardly accurate. The Iceland "low" is strongly developed in winter, but diffuse and feeble in summer. Moreover, its position shifts rapidly, and it is by no means always central south of Iceland. At Vestmannö, the southernmost meteorological station in Iceland, the ratio of easterly to westerly winds is 35:22 for the year as a whole, and 34:25 for the three summer months; i. e., westerly winds are about two thirds as frequent as easterly. Calms, also, are frequent in all months.—Editor.

On the Ireland, or steamship, route the main difficulty is the frequency of fog, amounting to from 10 to 25 per cent over almost the whole route. Over the western half of this route the winds are prevailingly from the two westerly quadrants, while farther east northeasterly and southeasterly winds may occur. These winds are generally fresh, with a force of from 4 to 5, but north of latitude 50 winds from south and south-southeast, attaining force 7, are rather frequent. Storm tracks are not found to any extent except on the southeastern edge of the Banks.

The most difficult part of the Azores route is at the beginning, as far east as about longitude 40, as this embraces the storm tracks and the fogs of the Newfoundland Banks; but it should be noted that this same portion of the route is the region of densest steamship traffic, as all the steamer routes to and from the chief American ports converge here. Thence on to the Azores the winds are moderate, not exceeding force 5, and from the westerly quadrants, while the weather is almost uninterruptedly fine. Between the Azores and the Portuguese coast moderate northerly breezes prevail.

The equatorial route begins in the zone of the northeast trades, which, however, extend only down to latitude 8 or 10 degrees north; then the belt of equatorial rains and calms must be crossed, until, somewhere of 5 degrees north latitude, the southeast trades are entered.

JULY.

The atmospheric conditions over the North Atlantic (see chart 6) assume their most definite summer character in July. Barometric depressions are rarely developed, and the weather is, therefore, prevailingly calm. The Azores "high" is now at its maximum and the non-periodic fluctuations of the barometer are small; accordingly the westerly winds between latitude 40 and 55 are steadier than in the other months, and rarely acquire much force. The northeast trades are feeblest at this season, and in this and the following month their southern limit lies farthest to the north. (See chart 3.) July is generally even freer from storms than June. Only southeast of the Banks are storms more frequent; while elsewhere over the ocean their frequency is everywhere less than 4 per cent. Hurricanes are very rare in July. Thus, of 216 hurricanes, only 29 have occurred in this month, or an average of one or two each year. (See chart 8.) Frequency of fog is at a maximum in July. On the Banks there are more than 300 hours of fog, on an average, during the month; while the limit of the region having more than 100 hours extends far to the eastward, but not farther south than the fortieth parallel.

The weather conditions on the Greenland route are characterized by the fact that the storm tracks, particularly those of the deeper depressions, have shifted farther to the north. On the Labrador side the winds blow mostly from the northwest, while nearer Greenland easterly winds, up to force 5, are of more frequent occurrence. Between the southern end of Greenland and the Hebrides light breezes from the westerly quadrants prevail, but cyclonic disturbances, moving chiefly from west to east, are still likely to be met with. On the direct (steamship) route the winds are also chiefly from westerly quadrants, and in midocean prevailingly from southwest. Cyclonic storms are rare on this route in July, and the weather is, therefore, usually fair. Between Newfoundland and the Azores much fog prevails on the first part of the route, with winds mostly from the southwest quadrant, but calms are frequent. On the equatorial route the northeast trades have retreated nearly to the Cape Verde Islands, while the southwest trades have shifted somewhat northward. Hence unfavorable winds may be expected over the greater part of the route.

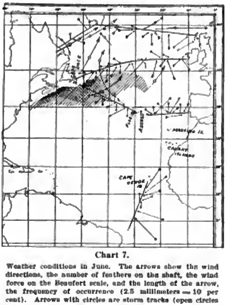

Chart 7.

Weather conditions in June. The arrows show the wind directions, the number of feathers on the shaft, the wind force on the Beaufort scale, and the length of the arrow, the frequency of occurrence (2.5 millimeters = 10 per cent). Arrows with circles are storm tracks (open circles indicate barometric minima of 730-740 millimeters; circles with dot, minima of 70-730 millimeters).

▨ 10—25% fog. ▩ 25—50% fog. ■ 50% fog.

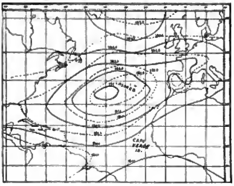

Chart 6.

-------- Isobars in July. ———— Isobars in August. (Pressure in millimeters.)

AUGUST.

The barometric conditions are similar to those of July. The trade winds are farthest north this month. Storms are still rarer than in July, and only to the southeast of the Banks do they exceed 5 per cent. Secondary barometric depressions are frequent only north of latitude 55, but the winds between latitude 50 and latitude 55 are often very fresh, ranging up to force 8.

On the other hand, August is a month of frequent hurricanes. About 21 per cent of West Indian hurricanes occur in this month. Even in the neighborhood of the Cape Verde Islands these storms are likely to occur. Fogs are somewhat less frequent than in the previous month, but the fog area extends considerably farther north. On the Greenland route the winds are mostly southeasterly or northwesterly between Greenland and Labrador, while between Greenland and the Hebrides they are almost exclusively from the two westerly quadrants. (See chart 4.)

On the direct route, southwesterly and southerly winds of great steadiness prevail on the American side, while on the European side the winds are fresh and chiefly from the two westerly quadrants, though southeasterly winds are not rare. The winds and weather along the Azores route are similar to those of July. The equatorial route is unfavorable in August on account of the prevalence of contrary winds and the frequency of hurricanes.[3]

SEPTEMBER.

The quiet conditions characteristic of summer still generally prevail in September, and this month is further marked by the frequent occurrence of easterly winds between longitude 10 and 30 west on the New York route. Storms, however, are considerably more frequent than in the previous month, especially in midocean. Moreover, September and October are the months of most frequent hurricanes. Of West India hurricanes 32 per cent occur in September. The frequency of fog has greatly diminished. In general, September does not offer as favorable conditions as August on any route. (See chart 5.)

October and November develop the definitely unfavorable conditions which reach a maximum in December, the month of coldest, stormiest, and rainiest weather at sea, with a storm-frequency amounting to 30 per cent or more. The depth of the barometric depressions reaches 710 millimeters (27.96 inches) or under. The northerly routes are impracticable at this season, but conditions on the equatorial route are somewhat more favorable, as the northeast trades extend far south and on the northern border of the southeast trades about 10 per cent of calms may be expected.

Thus, for the three northern routes only the three summer months, June, July, and August, need be taken into consideration, while for the equatorial route the winter and early spring months are the most favorable. Which of these routes is the most promising from a meteorological standpoint? The general wind conditions on the Greenland route, for example in July, would seem to be not unfavorable, but against the selection of this route may be urged the generally low barometric pressure and the comparative frequency of storm tracks. Along the Ireland route one may generally count on fine weather and favorable winds in July. The Azores route has a dangerous stretch on the southeast border of the Newfoundland Banks, but is characterized elsewhere by the great stationary Azores "high," giving generally fair weather, but winds mostly at right angles to the direction of flight. The character of the equatorial route depends upon the development of the southeast trades at their northerly border.

Hence, the most favorable routes in a meteorological sense are the Ireland route and the Azores route, in July. As to the distance to be covered, the most favorable, except the Iceland route, is the Azores route, on which only 2,000 kilometers (1,243 miles) must be made in one flight, a distance which can be covered by our modern machines. Next comes the Greenland-Hebrides route, with a lap of 2,200 kilometers (1,367 miles). The greatest distance to be made in one flight on any route is 3,100 kilometers (1,926 miles) on the Ireland route, and this would be increased to about 3,500 kilometers (2,175 miles) if the aviator kept close to the international steamship routes.

The third point to be considered is the density of traffic over the various oceanic regions in question. As will be seen from charts 1 and 2, the Greenland routes are altogether outside the area of steamship travel. The main stream of travel extends from Bishop Rock or Fastnet along a great circle to longitude 47 west and latitude 41⅓ north on the westbound routes, while the eastbound routes lie about a degree, or 111 kilometers (69 miles) farther south. Hence, in order to take advantage of this main artery of travel, when flying over the Ireland route, a détour is necessary. This détour is to be recommended under all circumstances, for if anything should happen to the machine over the comparatively little traveled northern waters the aeronauts would in all probability be lost, whereas on the great steamship track the prospects of a rescue would be good, provided the wrecked aviators could attract attention to their plight, if not by wireless telegraphy, perhaps by smoke signals or the like. If apprised in advance of the flight, vessels would keep a sharp lookout for a case of this kind. The conditions are very favorable on the Azores route, which crosses the most important vessel tracks between Europe and North America and between the English Channel and Central America. Just at the most dangerous part of this route would be met the big fishing fleet on the Banks, which would greatly enhance the safety of the journey. The eastern part of this route, between the Azores and Portugal, is also much frequented by vessels, as it intersects the steamship routes to South America, Madeira, Teneriffe, and West and South Africa. The steamship routes from Gibraltar to North America are almost identical with the route of flight. The equatorial route runs along the steamship track to Brazil, but otherwise this portion of the ocean is little traveled.

Hence from this point of view the Azores route and the Ireland steamship route stand at the head. A physiological factor favoring the Azores route is the relatively warm and pleasant climate.

As a last important point, the purely nautical conditions of the various routes must be considered. These include (1) deviation from the course and its results, (2) the chances of a good landfall, and (3) the possibility of verifying one's course. On the northernmost route the conditions are not promising, as in case of getting off his course or meeting with an accident the aviator would be helpless, while the coast is of no service, on account of the mostly onshore winds, and offers little shelter. There are no passing ships to

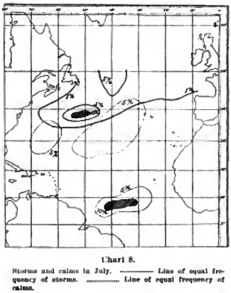

Chart 8.

Storms and calms in July. ———— Line of equal frequency of storms. .... Line of equal frequency of calms.

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[3] True hurricanes—i. e., tropical cyclones—are probably rare on this route.—Editor.

enable the aviator to verify his course. More favorable conditions obtain on the two middle routes, especially on the Ireland steamship route, on which both the landfall and the checking of the course offer no difficulties. On the Azores route the landfall at the Azores offers considerable difficulty. To be sure these islands stretch over about 600 kilometers (373 miles) in longitude, but they are much less extensive in latitude. A considerable deviation from the course might, therefore, be fatal, as the next land on the route in this direction would be the Madeira, Canary, or Cape Verde Islands, or the European or African continents. However, this obstacle is not decisive if watchful navigation be maintained, with the fair weather prevailing almost constantly in this region. In case of necessity an observation for position would need to be made, and this can be done from an aeroplane within an error of 50 miles or so.

The following table summarizes the features of the various routes, which are arranged in order of merit with respect to the factors specified:

Distance.	Meteorological.	Density of travel.	Navigation.	Physiological (as to climate and duration of flight).
1. Iceland	Ireland and Azores	Ireland and Azores	Ireland	Azores
2. Azores	....	....	Azores	Equatorial
3. Greenland-Hebrides	....	....	Equatorial	Ireland
4. Equatorial	....	....	....	....
5. Ireland	....	....	....	....

It is evident from the above that by far the best routes are the Ireland route and the Azores route, and with such aeroplanes as we have to-day the Azores route appears to be entitled to first consideration. The greatest distance to be flown is about 1,200 miles; the weather conditions are, at the worst, not unfavorable; and it is possible to break the journey with a day of rest. Given, however, aeroplanes capable of covering the great distance of the Ireland route, the latter would, as a non-stop flight, possess a greater sporting interest.

Hence, for the aeroplanes of the present the Azores route; for the great aircraft of the future, the Ireland route.

A few words may now be said regarding the nautical equipment of an aeroplane for an ocean flight. The first principle to be observed under this head is not to burden oneself too heavily with instruments, etc. The proper instrumental equipment is about as follows:

a. With a passenger. 1. A reliable compass, suitable for aeronautical use. Such compasses are obtainable, but cost a little more than ordinary instruments. The aeronaut should beware of instruments which have not been tested and found to be in good working order. The money paid for a good compass will be well expended. 2. A normal observing sextant for horizon observations. Leveling instruments are hardly necessary in this particular case, and an aeroplane hardly offers a suitable platform for their use. 3. A good timepiece set to Greenwich time. 4. If desired, a device for sumner line determinations, such as the Orion or Brill instrument.

b. Without passenger. In this case astronomical observations are impossible, and the corresponding apparatus may, therefore be omitted. A compass is, of course, indispensable.

In both cases an hypsometer will, naturally, be needed. As to a chart, the general map of the North Atlantic will suffice, and from this may be cut a strip corresponding to the selected route, which may be mounted on one or two rollers. In connection with this it will be advisable to take a parallel ruler.

We have already spoken of the possibility of getting position by signal from passing ships. It would be well for the aviator, some time before beginning his flight, to request all the great steamship companies to instruct their captains to hoist the international signal for their position (probably to whole degrees) as soon as they come in sight of an aeroplane on the high seas, and without waiting for a request from the aviator. A pilot having, alongside of his chart, a table of such signals can then ascertain immediately his own position, and adjust his course accordingly. The author feels confident that such a request would be cheerfully complied with by the steamship companies, and thus, for the aviator flying alone over one of the two middle routes, a great difficulty would be disposed of.

One more point remains to be mentioned. We have purposely refrained from considering the possibility of a water-landing or a renewal of the fuel-supply on the high seas, because, in the author's opinion, such a procedure would be equivalent to abandoning the flight. The reason for this opinion is the unseaworthy character of hydro-aeroplanes. Why these craft are not yet staunch enough for the high seas need not be discussed here; we will only remark that there is a preliminary problem to be solved before it will be possible to solve completely the problem of the hydro-aeroplane. All this has, however, nothing to do with the transatlantic flight. Provided only the motor holds good the feat is possible without breaking the journey by alighting on the water, and nowadays when a thing is possible it is done.

Musical Sensation

VERY curious experiments, especially interesting to musicians, have just been made by Dr. Marage. In a recent study, he had shown that for each vowel there exists a note on which a minimum of energy is necessary to make it heard; that is, indeed, the origin of the telephonic "Hello." Dr. Marage, in a paper presented before the Academy of Sciences by Prof. d'Arsonval, studies the sensibility of the ear for certain musical sounds. The question was to know the impressions experienced by an audience composed of musicians, savants, literary men, and society people, while listening to the same pieces of music of the sixteenth and seventeenth centuries, performed successively on the piano and on instruments of the period: clavecin, clavichord, lute and viol. To realize this experiment, the three hundred pupils who follow the classes at the Sorbonne of the physiology of speech and singing have been divided into two series. The pupils were to note their physiological and musical impressions. Out of an audience of 300, only 142 copies were given in; that is to say, that over 50 per cent of the pupils had no impressions or did not wish to write them down. And yet the copies were anonymous. The other half, however, on the contrary, experienced very diverse sensations. The pupils who gave in their copies were divided into 51 professional musicians or singers; 25 cultivated persons—that is to say, with a good knowledge of music and studying it from a taste for the same; 34 with no musical knowledge; 13 scientific persons, professors, pupils of the Polytechnic School, of the Central School of Civil Engineers, or of the Sorbonne; and 19 literary professors or pupils. The copies, judged from the point of view of the analysis of the sensations, have given the following results: The cultivated come out at the top of the list with 77 per cent of good copies; professors of singing and music come next with 62 per cent. The scientific pupils are greatly superior to the literary; 47 per cent of the first against 35 per cent of the second gave in excellent copies. The literary people make long descriptions, interesting and agreeable to read, but it is often difficult to discover what are the sensations they experience. The scientific, on the contrary, have clear ideas expressed in a few lines. Concerning the physiological impressions, it is to be remarked that almost all the audience is at first disagreeably impressioned by the thin and metallic sounds of the clavecin, then the ear gradually gets used to these chords, new to it, and then it finds in them certain qualities. The grave sounds of the viols are immediately agreeable to the audience. A curious phenomenon of suggestion has also been observed by M. Marage. After a first performance, it was decided to change the piano. The instrument was new, and it had been thought that the sounds it gave forth were not very harmonious. Twenty musicians had expressed the desire to be present at the second series, at which the same programme was to be performed. They all noted down that the new piano was very superior to the first one. Now, for some reason unknown to M. Marage, the instrument had not been changed, and was the same at both series. To sum up, Dr. Marage wonders if musical critics are not often influenced by the special dispositions of their auditive nerves. The particular action of vibrations on each nervous system, the habit of hearing certain sounds, and, lastly, the previous education, must deprive the artistic criticism of the value possessed by the scientific criticism.—*Chemical News.*

Problems of Stability in Aeroplanes

CONTRARY to the general opinion, the view is not held by the most competent authorities that perfect automatic stability is a desirable attribute. A certain degree of inherent stability, especially in the longitudinal sense, is already possessed by most modern aeroplanes, and would at the present time appear to be adequate. With lateral stability the case is different, for until the present time this has been obtained only in a minor and insufficient degree, and in machines of certain types it is precarious to the point of depending for its maintenance wholly on the intervention of the pilot. At first sight it might well seem as if no aeroplane could be too stable. Since longitudinal stability is largely a question of maintaining flying speed, the view is correct enough in that limited sense, provided that stability in this case does not preclude speed variation. On the other hand, too great a degree of stability in every other respect must necessarily render an aeroplane insensitive to control, and interfere with easy steering. As a case in point we may take a well-known aeroplane possessing as high a degree of automatic stability as any hitherto designed. In calm weather this machine behaves admirably, requiring practically no controlling from the pilot; but in a gusty wind it behaves in such an erratic manner as to render it a matter of the greatest difficulty to steer an accurate course.

A well designed aeroplane, on being struck by a gust and being tilted up on one wing, recovers automatically, provided the gust be not too violent, and the first oscillation will be immediately followed by one in the opposite direction until a level keel is again attained. Naturally, it is desirable that these oscillations should be damped out as quickly as possible, and should in any event be prevented from attaining too much amplitude. Every consideration points to the conclusion that lateral stability should never be unduly exaggerated.

But there is a final factor to be taken into account. Perfect automatic stability loses its disadvantages for an aeroplane flying in comparatively calm air, and in those conditions even becomes a positive advantage, since it relieves the pilot of his controlling duties and leaves him free to devote himself to others, such as observation. The best solution, therefore, would appear to be to devise some form of automatic stabilizer capable of being set in action or cut off at any moment by the pilot, who would thereby have at his disposal the dual advantage of automatic stability in calm air and of perfect controllability under all conditions.

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The monument of the world's postal union in Berne, where the Swiss National Exhibition is being held.

"The Village"; Swiss National Exhibition, Berne, May 15th to October 15th, 1914. "The Village" is a faithful portrayal of Swiss village life.

SWISS NATIONAL EXHIBITION AT BERNE.—[See page 72.]

The Electrical Industries in Japan*

An Instructive Review of Their Present State

By Prof. Shunkichi Kimura, Ph.D.

Consulting and Commercial Engineer for Electrical Industries and Applications, Momosono, Nakano, Tokio, Japan

The protective policy and the encouragement of home industries now in vogue in Japan for averting the disastrous trend of financial conditions as well as for improving the national standard of wealth, have created a disturbance in the system of industrial commerce which has developed during the last thirty years. But at the same time a new and interesting field has been opened up for those who will accommodate themselves to the changed conditions or for those who keep a smart lookout for new opportunities. On our side we ought not to aim at independence from the industries of the West, which might lead to our isolation; on the contrary, the relations between the industries in this country and those in the West should be made much closer than ever. Nor should our object be the exclusion of foreign arts and inventions, which will certainly lead us to sterility; on the contrary, importation and exportation must be mutual and must be encouraged to an ever-increasing extent. Home industry in Japan is progressing, no doubt, but much more slowly than in Europe and America, and in the case of electrical industries Japan is from ten to fifteen years behind other countries in the West.

In the domain of electrical industries, water-power plants throughout the country are numerous and widely distributed; those mountain streams with shallow basins, long regarded as the cause of all kinds of troubles, are now being rapidly turned into sources of electric power. According to the most reliable report, those water-power plants alone which can be most easily and economically turned to electric power amount in the aggregate to about ten million horse-power; of this only three hundred thousand have already been utilized for the public, while one half of it is in actual operation, and that mostly for lighting and power in cities and towns. Such sources of power will mean a great deal in future when they are economically employed on the spot, not with the object of selling the electricity, but in manufacturing commercial products with the energy, which may be used as transmissible motive power or can easily be transformed into intense heat or a powerful electrolytic agent.

Changes in the order of things are perplexing, not only to the foreign merchants and native contractors, but also to home industries themselves. To return to electrical industries, ordinary types of motors, generators, and transformers are now made here of creditable quality, but iron and steel of special descriptions are imported every year to a great amount. Patent rights and manufacturing processes may be acquired from abroad, but without the help of trained foreign engineers, at least during the trial stage, it will be difficult to turn out articles of high-class quality. Investigations are being made, no doubt, to a certain extent, but the progress is slow and the results doubtful, as expenses for research work are generally too heavy to be borne; in the meantime, foreign countries will make great progress, and even when the researches lead to success the market here is very small and the means for international business extremely limited. Apparently there is a great boom in electrical industries in Japan, yet if we deduct the imported articles, only a little will remain as the genuine product of home industry. One hears from contractors that all kinds of machines, both mechanical and electrical, are still imported through their hands, without any change, for places where reliable machines are in demand. These contractors are generally large firms, having long experience and trained hands. The so-called importers, whose business is conducted by foreigners with low-grade native employees, and without respectable Japanese associates, seem to have felt the effects of the change.

The study of all systems, both those which are obsolete and those which are still flourishing, must enrich one's experience and judgment and enable one to meet the changed conditions. Joint capital, joint management, exploitation of patents, and manufacturing processes—these are, generally speaking, worthy of recommendation. Of the present system of industry, as regards either sale or management on a scale fit for cheap production and a wide market, Japanese men of business have as yet had only short experience. Those industries which are now flourishing do not belong to the class of pioneer industries, and the channels of business have been prepared by the so-called importers. It will be clear that the co-operation of foreigners, trained in international business is desirable, while for the manufacture of articles, complicated as regards process, delicate in fixing, or precise in measurement, the co-operation of trained foreign hands will be imperative. But on the side of management, dealing with customers, understanding public taste, and the proper ways of speaking and writing, or in selecting the right person to communicate with—in short, in all that cannot be reached by reasoning and calculations alone—the co-operation of Japanese managers will be desirable. Further, the protective policy of the government and its general encouragement of home industries will be met by joint capitalization. The days of monopolizing interests are now gone forever, and the day has come for mutual interests with joint responsibility, the rights of both parties being justly considered and clearly defined. There are already instances of such joint capital and joint management, some of which are apparently failing, while others are likely to succeed. If we look closely into these cases, however, it will not be difficult to find out ample reasons for these failures and successes. Both kinds are equally full of lessons for those who would avail themselves of the opportunities now offered by the changed conditions. Such a change is ever to be welcomed, and here lies a chance for new men in the field.

To me it seems that foreign firms and inventors are too neglectful of securing their patent rights in Japan. All the details of their inventions, so far as they are expounded in the technical papers in their own lands, are of course open to public scrutiny here, and the so-called inventors here may resort to these papers and utilize them for their own benefit. In granting patent rights in this country, officials do not search through foreign patent records; it is advisable, therefore, that the real inventors or the lawful possessors of patent rights should pay more attention to this matter. The best thing to be done would be to secure their patent rights here, and to look at once for their exploitation, either in the form of co-operative working, or of selling the right, or else on the basis of royalties. It is to be remarked, however, that the market here, being national and not international, is, of course, too small for large industries; and the most profitable inventions will be those dealing with the commonest kinds of articles, widely used in industry or by the public, or else such as will replace others which have already created a good market in this country.

In the exploitation of inventions and manufacturing processes there is one thing which might with benefit be resorted to. This is the publication in industrial or trade journals, in the Japanese language, of the general nature of the invention, of the manufacturing facilities, of the properties of articles made, of places in which they may be most profitably employed, and so forth, accompanied with cuts or illustrations, and, when necessary, with the result of scientific testings, and with anything which will instruct people and induce them to make further inquiry. A few lines of advertisement in daily papers offering for sale the patent rights are of course useless, since their nature can only be understood by a few specialists, but not by the men who might take real interest in the transaction.

The following brief survey of the present state of electrical industries in Japan may be of some interest. The data have been collected within the last six months in the factories throughout the country and under my own personal observation.

Motors, generators, and transformers are made here in large quantities, to meet a very great demand which increases every year. As to the size, generators have been made up to 6,000 kilowatts giving very good results under test. There are two large factories with long experience, one in some connection with the General Electric Company of the United States of America, the other as a part of a dockyard. Besides there is a large factory adjoining and in possession of a copper-mine, which promises to have a splendid future. Smaller factories which turn out smaller articles are many in number, and compete keenly with each other. All special iron and steel parts are imported, and these factories have always to keep them in stock, thereby causing unnecessary loss and inconvenience. Special types of machines, and those directly coupled with water and steam turbines, have been supplied by the importers and contractors; but even these are now being made in Japan to a small extent.

Carbon filament lamps are made here in a satisfactory way, though some difficulty is experienced in making them for 220 volts, and the filaments of superior qualities are all imported. Tungsten lamps of ordinary size are also made here in many places, both drawn and squirted wires being imported. Large factories in Kawasaki and Osaka are turning out tens of thousands of lamps every day, yet hardly enough to meet the public demand.

Porcelain insulators of good quality are made here to a large amount, leaving no room for importation, as suitable raw materials are plentiful in Kiushiu and other places, but the manufacture of straight and uniform tubes seems to be limited to the length of about thirty centimeters. Most of the large factories have reliable sets of apparatus for testing insulators, but these latter, when furnished with transmission wires, sometimes give way with the normal working voltage. Among solid insulating materials other than porcelain, ebonite is the only sort which can be made in a good quality. No substitutes for ebonite nor any insulators to meet special circumstances are yet forthcoming, although such forms as lamp-sockets or ball insulators for trolley lines are made to a great extent. Mica is largely found in Corea and Mutchu, though the quality is not high grade. It appears exposed as rock or rather as an assemblage of small rocks, and there is a prospect of finding the mineral of good quality in deeper places in the mines. It is still good enough for making some sort of micanite; but there was no factory for it till very recently, when some attempts in this direction have been made with good prospects of success. Superior kinds of mica are imported through London firms from India, and in most of the electric workshops it is used even where smaller pieces of inferior quality are good enough for the purpose. Engineers do not seem yet fully to understand the values of the different sorts of the micanite. Indeed, it is now a general feature here, that in spite of the keen competition under which they are struggling they do not look for the new materials which they may use with much profit in place of old ones, and in order to avoid the unnecessary expenses in the production of their articles. Very recently a patent right for bakelite has been acquired, and the manufacture will begin after one year. India-rubber insulating tapes are made in many places, usually on a small scale and in a very primitive way. Insulating compounds and varnishes are made only to a small extent, and none with special features are yet touched upon. Transformer oils are made at oil refineries, but it is not known whether they meet the strict requirements of electrical engineers. All other oils for making varnishes and compounds are imported, and they secure good prices.

Ammeters, voltmeters, and kilowatt-hour meters are largely imported. Ammeters and voltmeters for alternating current and direct current are also made here on a fair business scale and supplied for use with small motors, but they serve for indicating rather than for measuring, and the consumers of electric power in general are indifferent. I have seen such meters in process of calibration by an ordinary workman with no proper education for such work, who was giving an allowance of 20 per cent either way, and calibrating with the fluctuating city supply as the electric source. There are some factories, however, where they make switch-board instruments, accurate to within 3 or 4 per cent, supplied with the generators made by themselves, but these cost much more than imported ones made by well-known specialist firms in America and Europe. There is no manufacturer of instruments of precision fit for scientific use. For hot-wire instruments there is difficulty in obtaining proper wires. In some factories resistance-boxes are made, but with materials having high temperature coefficients. The employment of physicists in factories began only a few years ago, and there are still places where men with no proper education hold the place of chief engineer. There is no place such as the National Physical Laboratory, or the Bureau of Standards, with a staff of the highest scientific reputation and with adequate modern equipment for research work. The development of the potentiometer must help them a great deal, but I have not seen at any commercial industrial workshop a really good potentiometer from well-known makers, and preserved in perfect condition, nor have I seen a battery of secondary cells for the electric source in calibration or testing of direct current instruments, or in driving a motor-generator for alternating current instruments. Such special instruments as the oscillograph are still considered a luxurious equipment in places where they are much needed; but ohmmeters and such like are used to a great extent. Those meters, which serve in selling and buying electricity, must now pass the examination of the Teishinsho (Department of Communication). Among these meters, tariff meters are imported to a large amount, but competition being keen, and under the public idea that electric apparatus has no fixed price, they are sold at half the catalogue price, and in addition one quarter of the selling price is paid for the fee of examination. The number of these meters examined at the Teishinsho last year reached 38,000, and the figure increases every year at a rapid rate.

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* Reproduced from the *Journal of the Royal Society of Arts.*

Resistance Materials.—None of the alloys used as the materials for electric resistances, except a small amount of German silver, are made here, and the manufacture of such alloys is in a very primitive stage. Consequently all heating elements must be imported.

Rubber works are in a prosperous condition, but not sufficiently so to stop the importation entirely. In former times these rubber works—the manufacture of ebonite and other insulating materials—were a part of the electrical industry. But they have now found their proper sphere, making such articles as toys, boots, mats, hose, tires, and packings, and the rubber works for the purpose of insulation have now become a part of wire and cable factories. Good rubber is, of course, imported from South America through London and New York firms, inferior quality rubber comes from the Straits Settlements, while the experimental cultivation of the tree in Formosa is likely to end in disappointment.

Wires.—Copper wires of all descriptions, from power cables down to silk-covered wires and rubber cored, are made here almost to the entire exclusion of imported articles, and all these factories are apparently in a prosperous condition, though competition is very keen in this as in other industries. Enameled wires are made in some of the factories, but the demand is still small and not yet established. Owners of copper mines and refineries have begun to make wires themselves, and the factories with no mines of their own are feeling a handicap in this respect. Copper wires of small diameters are drawn up to No. 50 S.W.G.; fifteen years ago I had to wait six months to import a piece of No. 42.

Dry cells are made in many places on a small scale, but the demand is increasing every year. Most of the factories do not possess the proper apparatus for testing their products, the general public accepting them untested, while in supplying governmental customers rigorous specifications are observed. Dry cells fit for storing, made of the type in which some liquid is poured in at the time they are used, are in demand by the army, the navy, and in the telegraph and telephone departments. Secondary cells of lead type are now made in two or three places, but the greater part of the demand, which is increasing every year, is supplied by importers. Those who are going to install them naturally pay attention to the life of the cells, and therefore look for the products of well-established foreign factories, native factories being still too young to insure good records for their products. Governmental customers use the native products, because they are instructed to do so, and they have no personal interest in the question.

Electric carbons for dry cells and for arc lamps, and also those carbons which do not require special processes, are made in many places, though on a small scale. Thick carbon rods for searchlights and carbon granules for telephone work are not yet made here in proper quality; carbon brushes, though made, are much inferior to imported ones.

Telephone and Telegraph Apparatus.—Public telephones and telegraphs are government monopolies, and the apparatus, being fixed in form, are old in type, except in few instances where new inventions are employed by way of trials. Most of this public telephone and telegraph apparatus has been supplied by two firms, one purely Japanese and the other in close connection with the West, and the apparatus was subjected to severe trials according to the policy of the government. As to the telephone, any new apparatus may be used after government inspection, but the public is not very particular about it. Automatic exchanges are not yet installed for public service, but semi-automatic ones will some day take the place of hard-worked female operators.

Apparatus for Domestic Electricity.—Fittings for lighting used in Japanese houses are developing to meet the taste of the people; but those for buildings of foreign style, for offices and dwelling houses, which are increasing very rapidly, are imported articles. No electric irons are made here, nor any electric heaters or cooking utensils, while electric fans are only manufactured to a very limited extent. Suppliers of electricity are now competing fiercely with one another, but for current for lighting purposes only. When this contest comes to an end, and that will be very soon, the manufacture of all kinds of apparatus for domestic purposes will rise quickly to a state of prosperity.

Garage Hazards*

Modern garages, both public and private, besides being used for storing and housing automobiles, are usually more or less completely equipped to make repairs, and supplies of gasoline, and lubricants of various kinds are also stored about them, sometimes in considerable quantities. Explosions and fires are likely to occur from improper handling and storage of the gasoline, and accidents of many other kinds also happen. The following suggestions are made in the hope that they may tend to minimize the dangers to which garage employees, owners of automobiles, and other persons may be exposed, and to reduce the number of accidents due to carelessness and improper methods.

Gasoline should be stored in underground tanks that are located in a safe position. Most cities and large towns have ordinances that regulate the location and nature of such tanks, and fire insurance underwriters have also given careful attention to the subject. The tanks should preferably be placed so that in case of leakage the gasoline will flow away from neighboring buildings, instead of toward them. All pipes and connections used for conveying or storing gasoline should be examined frequently to detect any leaks that may exist, and if leaks are discovered they should be repaired immediately. The connection for filling the tank should be located outside of the garage, and the ground around this connection should slope away from the building, to carry off any gasoline that might be accidentally spilled during the process of unloading.

Smoking, the lighting of matches, and the use of open-flame lamps and blow torches or braziers, should be absolutely prohibited in garages. Kerosene and acetylene lights on automobiles should be extinguished while the gasoline tanks in the cars are being filled. It is dangerous to clean automobile engines and other parts of the car by the use of gasoline delivered in the form of spray, and when this method is used special care should be taken to see that there is no open flame in the vicinity. Oily cotton-waste and rags, and other similar oily and greasy material should be placed in metal cans when they are not in immediate use, and should be covered with closely fitting covers. Serious explosions are often caused in sewers by gasoline and oil that have escaped into them through the waste pipes from washing stands in garages. In many localities laws or ordinances require the use of separators, to remove oil and gasoline from the water before it reaches the sewer, and we strongly advocate the installation of such separators, even when they are not required by law. Stoves or open fires should not be used in garages. The heating should be done by steam or hot water, piped from a heater located in a separate room or in another building. Chemical fire extinguishers, or boxes containing plentiful supplies of dry sand, earth, or sawdust, should be placed in every garage to be used in case of fire, and attendants should be warned against attempting to extinguish gasoline fires with water. Sawdust or sand is best applied by a broad, flat shovel, similar to a snow shovel.

Care should be taken to avoid collisions and other accidents when entering or leaving a public garage, particularly when there is but a single door or passageway, which is used both for entrance and for exit. If the driver cannot clearly see where he is going, he should sound his horn repeatedly, and proceed very slowly and cautiously. If a doorman is in attendance, his signals should always be faithfully heeded. The reckless or careless driving and handling of cars in public garages should be prohibited.

Great care should be taken when transporting automobiles on elevators in garages. As soon as a car has been run upon the elevator platform the brakes should be set up tightly, and it is safest to stop the engine until the level is reached at which the car is to be taken off. All parts of the elevator and its mechanism should be frequently and carefully examined, and any defects that are discovered should be remedied immediately. A gate of special construction and strength should be provided at every landing. Failure to retain control of a car and bring it to a stop before it strikes the gate has caused many a serious accident, where nothing more substantial than the ordinary elevator gate has been in use. A heavy horizontal bar, made up of two angle-irons with a core of wood between them, and placed about twenty inches above the floor level, will furnish protection in cases of this kind. The gates should be provided with locks that can be operated only by the person in charge of the elevator.

Electricity is ordinarily used in garages to furnish the motive power for the elevators and for the various machine tools that are used in the repair shop, and all possible precautions should be taken to guard against accidents that may be caused by its use. Accidents are often caused by the arcing of switches on account of defective design, or because of lack of attention in operating them. Motor-starting switches having a no-volt release may cause accidents if they are allowed to get into bad condition, so that they fail to return to the starting position properly. In such a case a flash may be produced the next time the motor switch is thrown in, and the attendant may be burned. Accidents also occur when replacing fuses, because of poorly designed fuse holders. Before renewing a fuse the switch should always be opened so that the power is cut off. It is important for plug connectors to be of an approved type and well insulated, so that it will be impossible to get a shock from them. Flexible extension cords should be thoroughly insulated and should be kept in good condition; and they should not be permitted to lie in pools of water or oil that may have collected on the floor.

Good lighting is important in all parts of the garage and repair shop, and when sufficient daylight is not available an adequate number of artificial lights should be provided. These should be of an appropriate type, and they should be properly located, and provided with suitable reflectors. Nothing should be used but incandescent electric lamps. The bulbs inside the garage should be protected by wire-mesh guards, and those that are located near the gasoline supply, or where gasoline is handled, should be inclosed in stout vapor-proof glass globes. All feed wires should be placed in conduits, or be insulated in some other equally effective way. Fuse boxes and switches should be located where gasoline vapors cannot reach them.

All belts, pulleys, gears, exposed shafting, and other dangerous elements and places should be effectively guarded, and clutches or mechanical belt shifters should be provided wherever they are needed. Tools should be kept in good condition, and any that are broken and defective should be promptly discarded.

The stock rooms should be kept in an orderly condition, and all spare parts, stock, materials, and tools should be arranged in a neat and orderly manner. Tools and materials should not be left lying about on the floors, where persons may stumble over them. Particular care should be taken to keep passageways and stairways free from obstructions. Drivers of cars, repair men, and others who may have occasion to start or run automobile engines, should carefully heed the suggestions that are given with regard to the operation of the engine.

Public garages usually provide compressed air for inflating tires and for other purposes, and thoughtless persons sometimes cause injuries to others by attempting to play practical jokes with it. This is an extremely dangerous practice, and it should never be allowed.

Many of the accidents that occur in garages are caused by thoughtlessness and carelessness, and others are due to lax methods, to the omission of thorough periodical inspections of the various parts of the building and machinery, and to other causes. Care combined with faithful attention to details of every kind, will result in a considerable reduction of these accidents, and will amply repay the owners of garages in many ways.

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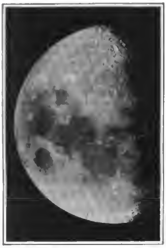
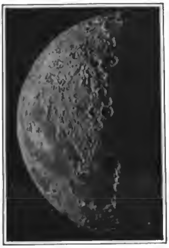
* Reproduced from *The Travelers Standard.*

The Cable and Telegraph System of Alaska has been built up since the year 1900, when the United States Signal Corps, as a military measure, connected the scattered posts in that territory. Later, in order to obviate the necessity of sending orders and instructions over a telegraph line through foreign territory (Canada), the Alaskan system was connected by cable with Seattle, and other cables were laid between points in Alaska. The Washington-Alaska military cable and telegraph system now includes 2,693 miles of submarine cable, 1,046 miles of land lines, and 10 radio stations; and is operated by 5 officers and 200 enlisted men of the Signal Corps, whose achievements under difficult and dangerous conditions are, in the opinion of the chief signal officer, "worthy not only of high commendation, but of a place in the annals of the country." Now, according to the same officer, the time has come when this system is of little worth for military purposes compared with its value in developing the material interests of the territory, and its transfer to the Post Office Department is being urged upon Congress. It is hoped that this transfer may be effected during the present Winter.

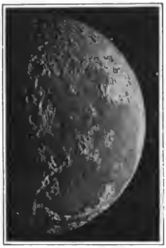
The Northernmost National Forest is the Chugach in Alaska; the southernmost is the Luquillo in Porto Rico.



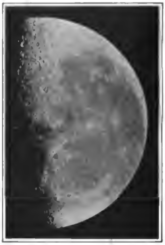
The moon, 8½ days old, as seen through the telescope.



First quarter, as seen on the sculptured moon.



Last quarter, as seen on the sculptured model.



The moon, 20½ days old, as seen through the telescope.

How a Plastic Model of the Moon Was Made

The Hemisphere of the Moon Constructed After Telescopic Photographs

By Herbert Collier

AFTER some years of telescopic observation with a Brashear telescope I determined to undertake the task of sculpturing the moon, mainly for the purpose of attaining greater familiarity personally with every detail of the surface.

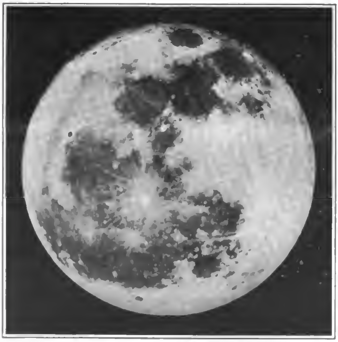
When you consider that the artist's model was some 240,000 miles away and had gained a reputation through the ages of being "fickle," some of the difficulties become apparent. Every day the moon has a different appearance—a new dress every sitting. As the sunlight creeps over the hills and lights up the mountain peaks, the view of yesterday changes, and quite a new aspect results. New valleys, great yawning craters jump into view with their dark depths untouched by even a glimmer of twilight, forming a background of Rembrandt's choosing. Continually the terminator, the irregular dawn line dividing light and darkness, is moving forward. On the earth this travels at the rate of about 1,000 miles an hour, completing the circuit of the globe in one day. On the moon this movement is about 225 miles per day, or nearly 10 miles an hour, for the earth turns round 29½ times to one revolution of the moon.

The details of craters—breadth and depth, a crag here, a precipice there—show clearly, contrasted by the shadows. But as the sun rises all this passes into blurry confusion in the fierce light of overhead rays. In such a moving picture there is a peculiar fascination. A new panorama presents itself each night to the watchful eye. To see it all is impossible, as the moon is in the visible sky for but a few hours comparatively, and nightly vigils with the telescope are sure to be interrupted frequently by cloudy weather or bad atmospheric conditions. Thus a long course of looking is obligatory before the student by personal observation knows the surface of the moon thoroughly.

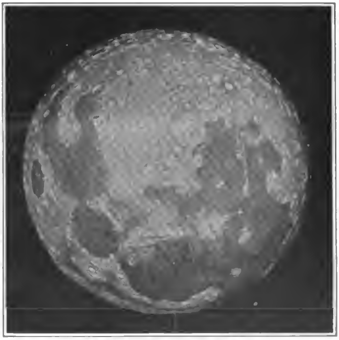
Though my eye had registered through the telescope thousands of impressions of the surface markings of the moon, I dared not trust that organ solely in transferring them to sculpture. Accuracy of result demanded exact measurements. Telescopic photographs present an unchanging record. They give an indelible impression of what is revealed, and such permanent record is ready for investigation at all times. Beyond question, photography pre-eminently has enabled astronomy to merit the title given it to-day "the most exact of sciences." Therefore I made, as the foundation of my work, the best series of photographs of the moon that the world has to-day, which is known as the Paris Atlas.

Twenty years ago M. Loewy, the gifted director of the Paris Observatory, with his colleague, M. Puiseux, undertook the systematic photographing of the moon. A unique telescope was designed, and elaborate plans and specifications made for this remarkable undertaking. The instrument was an ingenious combination of a huge object-glass or light collector nearly two feet in diameter and mirrors. Equatorially mounted and driven by clockwork, the refracting lens faithfully followed the object across the sky, while the mirrors, two in number, were so arranged as to convey the image thus secured through a tube in the wall to the eye-piece situated within a comfortable room. Here the camera was attached, and the men worked free from the usual bodily discomforts associated with the ordinary telescope.

While some of the finest individual photographs of the moon have been taken by the great telescope at the Yerkes Observatory, which is the largest refracting telescope in the world, nothing can compare with the series secured by the Paris astronomers through years of devoted effort. Thousands of photographs were taken of the moon at all stages of its progress from new to full, and then on to new again. Possibly twenty would be secured one night and but one selected as good enough to enter the atlas. These pictures form a wonderful catalogue of the topography of the moon, presenting far more minute details of the surface of our own satellite



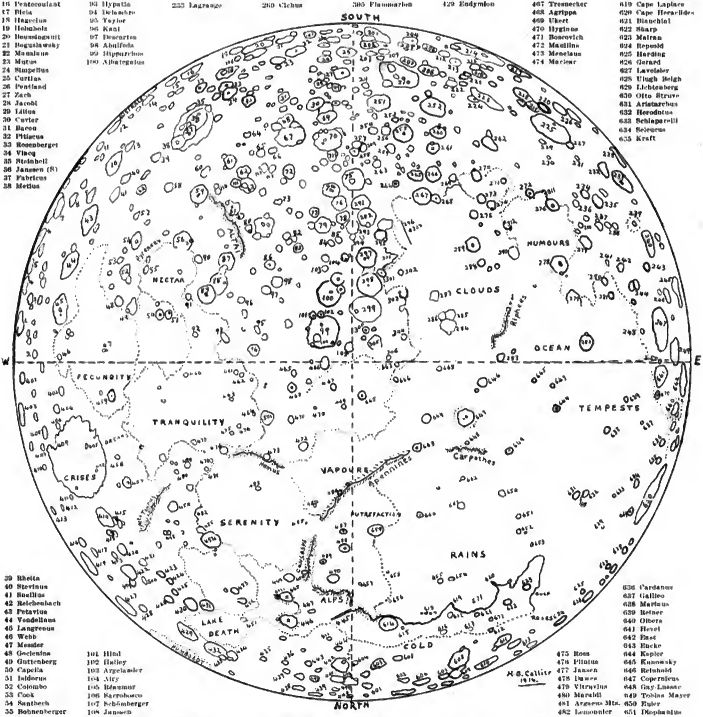
Full moon as seen in the telescopes.



Full moon as it appears on the model.

NAMES CORRESPONDING TO KEY-MAP, LOCATING ALL PROMINENT OBJECTS ON THE MOON.

1	Kästner
2	Maclaurin
3	Lapeyrouse
4	Ansgar
5	Behaim
6	Hecatäus
7	Phillips
8	Legendre
9	Hase
10	Furnerius
11	Marinus
12	Oken
13	Fraunhofer
14	Brisbane
15	Hanno
16	Pontecoulant
17	Biela
18	Hagecius
19	Helmholz
20	Boussingault
21	Boguslawsky
22	Manzinus
23	Mutus
24	Simpelius
25	Curtius
26	Pentland
27	Zach
28	Jacobi
29	Lilius
30	Cuvier
31	Bacon
32	Pitiscus
33	Rosenberger
34	Vlacq
35	Steinheil
36	Janssen (S)
37	Fabricus
38	Metius
78	Blanchini
79	Playfair
80	Fermat
81	Pons
82	Azophi
83	Abenezra
84	Donati
85	Faye
86	Almanon
87	Catharina
88	Cyrillus
89	Theophilus
90	Beaumont
91	Mädler
92	Torricelli
93	Hypatia
94	Delambre
95	Taylor
96	Kant
97	Descartes
98	Abulfeda
99	Hipparchus
100	Albategnius
220	Wargentin
221	Weigel
222	Rost
223	Schiller
224	Bayer
225	Schickard
226	Inghirami
227	Lehmann Bouvard
228	Drebbel
229	
230	Clausius
231	Lacroix
232	Piazzi
233	Lagrange
256	Pictet
257	Nasireddin
258	Miller
259	Sasserides
260	Wilhelm I.
261	Heinsius
262	Hainzel
263	Lexell
264	Hell
265	Gauricus
266	Wurzelbauer
267	Pitatus
268	Hesiodus
269	Cichus
292	Purbach
293	Lacaille
294	Delaunay
295	Thebit
296	Right Wall
297	Arzachel
298	Alphonsus
299	Ptolemäus
300	Wm. Herschel
301	Alpetragius
302	Lassell
303	Davy
304	Lalande
305	Flammarion
416	Hahn
417	Berosus
418	Burckhardt
419	Gauss
420	Geminus
421	Berzelius
422	Messala
423	Franklin
424	Cepheus
425	Oersted
426	Volta
427	Long
428	Mercurius
429	Endymion
452	Burg
453	Plana
454	Posidonius
455	Chacornac
456	Römer
457	Macrobius
458	Proclus
459	Taruntius
460	Maskelyne
461	Sabine
462	Ritter
463	Arago
464	Sosigenes
465	Godin
466	Rhaeticus
467	Tresnecker
468	Agrippa
469	Ukert
470	Hyginus
471	Boscovich
472	Manilius
473	Menelaus
474	Maclear
604	Epigenes
605	Fontenelle
606	Anaximenes
607	Carpenter
608	J. Herschel
609	Anaximander
610	Pythagoras
611	South
612	Harpalus
613	Xenophanes
614	Plato
615	Plato A.
616	Condamine
617	Bouguer
618	Straight Range
619	Cape Laplace
620	Cape Heraclides
621	Bianchini
622	Sharp
623	Mairan
624	Repsold
625	Harding
626	Gerard
627	Lavoisier
628	Ulugh Beigh
629	Lichtenberg
630	Otto Struve
631	Aristarchus
632	Herodotus
633	Schiaparelli
634	Seleucus
635	Kraft



39	Rheita
40	Stevinus
41	Snellius
42	Reichenbach
43	Petavius
44	Vendelinus
45	Langrenus
46	Webb
47	Messier
48	Goclenius
49	Guttenberg
50	Capella
51	Isidorus
52	Colombo
53	Cook
54	Santbech
55	Bohnenberger
56	Fracastorius
57	Borda
58	Neander
59	Piccolomini
60	Stiborius
61	Riccius
62	Rabbi Levi
63	Zagut
64	Nicolai
65	Büsching
66	Buch
67	Maurolycus
68	Barocius
69	Licetus
70	Stöfler
71	Fernelius
72	Frisius
73	Pontanus
74	Aliacensis
75	Walter
76	Werner
77	Apian
101	Hind
102	Halley
103	Argelander
104	Airy
105	Réaumur
106	Sacrobosco
107	Schömberger
108	Janssen
109	Horrocks
110	Rothmann
111	Lindenau
201	Newton
202	Moretus
203	Cysatus
204	Casatus
205	Klaproth
206	Wilson
207	Blancanus
208	Scheiner
209	Gruemberger
210	Clavius
211	Deluc
212	Kircher
213	Bettinus
214	Bailly
215	Zuchius
216	Segner
217	Mauren
218	Procylides
219	Nasmyth
234	Fourier
235	Vieta
236	Palmieri
237	Cavendish
238	Henry
239	Byrgius
240	Darwin
241	Zupus
242	Fontana
243	Crüger
244	Sirsalis
245	Trouvelot
246	Rocca
247	Grimaldi
248	Damoiseau
249	Riccioli
250	Lohrmann
251	Maginus
252	Longomontanus
253	Street
254	Saussure
255	Tycho
270	Capuanus
271	Ramsden
272	Vitello
273	Mercator
274	Campanus
275	Kies
276	Doppelmayer
277	Mersenius
278	Gassendi
279	Letronne
280	Billy
281	Hansteen
282	Flamsteed
283	Landsberg
284	Fra Mauro
285	Bonpland
286	Parry
287	Guericke
288	Lubiniezky
289	Bullialdus
290	Agatharchides
291	Regiomontanus
306	Mösting
307	Birt
308	Prom. Aenarium
309	Huggins
310	Liebig
311	Lee
312	Hippalus
401	Schubert
402	Apollonius
403	Neper
404	Firmicus
405	Condorcet
406	Auzout
407	Hansen
408	Picard
409	Cape Agarum
410	Alhazen
411	Eimmart
412	Oriani
413	Plutarch
414	Cleomedes
415	Tralles
430	Atlas
431	Hercules
432	De la Rue
433	Strabo
434	Thales
435	Democritus
436	Kane
437	Moigno
438	Euctemon
439	Challis
440	Gioja
441	Barrow
442	W. C. Bond
443	Ch. Mayer
444	Archytas
445	Alpine Valley
446	Aristoteles
447	Egede
448	Eudoxus
449	Alexander
450	Calippus
451	Baily
475	Ross
476	Plinius
477	Jansen
478	Dawes
479	Vitruvius
480	Maraldi
481	Argaeus Mts.
482	Lemonnier
483	Bessel
484	Aratus
485	Linné
486	Conon
487	Autolycus
488	Aristillus
489	Theaetetus
490	Cassini
491	Protagoras
492	Peirce
493	Bernouilli
494	Timaeus
495	Scoresby
496	Goldschmidt
497	Meton
498	Kirchhoff
499	Schumacher
500	Hooke
501	Cesar
601	Anaxagoras
602	Philolaus
603	Birmingham
636	Cardanus
637	Galileo
638	Marius
639	Reiner
640	Olbers
641	Hevel
642	Bast
643	Encke
644	Kepler
645	Kunowsky
646	Reinhold
647	Copernicus
648	Gay-Lussac
649	Tobias Mayer
650	Euler
651	Diophantus
652	Delisle
653	Gruithuisen
654	Helicon
655	Leverrier
656	Mt. Pico
657	Mt. Piton
658	Kirch
659	Archimedes
660	Timocharis
661	Lambert
662	Pytheas
663	Eratosthenes
664	Stadius
665	Pallas
666	Schröter
667	Sömmering
668	Gambart
669	Briggs
670	Cavalerius
671	Rainbow Bay
672	Maupertius
673	Foucault

than we know of our earth in many regions. The atlas was to me a guide book superior to a personal visit.

Fearful lest through lack of knowledge of the technique of sculpture I should waste much valuable time, I devoted fully six months to the study of this special feature. Then after consultation with a number of skillful artists I commenced operations.

Plasticine appeared best suited to the conditions under which I was to labor. It is non-drying and responds quickly to manipulation with a tool. A sitting of three or four hours, then a day or two, and another sitting just as my spare time permitted, proved plasticine an excellent medium for the purpose.

"How big shall I make it?" was a troublesome question which received answer in the selection of a scale of 180 miles to the inch. The moon having a diameter of 2,160 miles, thus brought my work to a like measurement of 12 inches. This was a convenient workable basis and proved satisfactory in every respect.

Only half the moon is visible to us at any time, and, strange to say, it is always the same half. A presentation to "royalty" demands that madam turns not her back to the regal chair. The approach, the bow, and the retreat call for skillful manipulation of her troublesome train, but she must keep her face ever to the front. So the moon sedately circles about the earth, and in true subservience observes this custom with remarkable precision. Every 29½ days the moon makes the circuit of the earth. At the same time she turns completely round. Yet with provoking constancy does she keep that one side to us. A slight swaying of the ball called "libration" permits a peep at times of a little more of the "edges" than the exact half, which really makes a total of about 59 per cent of the whole surface presented at different times to the earth. Consequently, half a sphere is really all we need to represent the details of surface characteristics of the earth's satellite, which are known to mankind. Therefore, as a foundation for my model I constructed a hemisphere of selected well-dried wood, laminated to prevent warping. The entire surface was then liberally treated with shellac. With a diameter of 11 inches this wood core allowed a blanket covering of plasticine ½ inch in thickness, thus giving a total diameter of 12 inches. A board 16 by 24 inches served as the base, and to this was fastened the hemisphere of wood and plasticine. The preparations were complete. Noting the date, May 1st, 1913, actual operations commenced. It was eight months later when the finishing touches were applied.

The photograph of a ball such as the moon presents some peculiarities. Take a 12-inch photo of a 12-inch ball. Superimpose the apparent centers, at the same time wrapping the photo paper around the face of the hemisphere. It is immediately apparent that they do not correspond and will not fit. The photo paper lacks practically seven inches of covering its prototype. The reason for this is quite evident. If the photo is kept flat and vertical lines projected to the surface of the ball, they coincide perfectly. This tersely explains the method I adopted on account of its simplicity in transposing scale calculations.

A photo of the full moon is very much like the preliminary sketch of the landscape painter. The seas, those great dark regions which even the naked eye discerns plainly, are nicely outlined. Some of the more prominent craters are noted. The more important mountain ranges are roughly indicated. But the details of all these are to be shown later. I first selected such a picture, an excellent one from the 5-inch Brashear telescope of D. B. Marsh, Sc.D., F.R.A.S. Being just 12 inches in diameter, it served the purpose admirably of an outline sketch or key. Various points on this were chosen and soon projected onto the model. As the work progressed craters and prominent physical features, visible only in other photos, were first given their proper locations on this key, that they might thereby be accurately placed on the model.

Each Paris photo gave in great detail one small region. Possibly but one or two craters of importance would be shown. Another picture of the same region, but under different lighting conditions, would change the apparent physical features to a remarkable degree. Thus a number of pictures of every district, showing the changes produced by sunlight coming from the east or from the west, must be carefully compared in order to arrive at a full understanding of the real topography. With a hundred such photos before me constantly, this task was by far the greatest and of prime importance. There are no twilight shadows on the moon. A glance at a dark spot may lead to the conclusion that a great hole is there, to which the sunlight has not as yet been admitted. Further investigation of it in other pictures reveals the fact that there is no such cavity, and that the shadow is due to the peculiar conformation of an intervening hill. Though the shadows thus appear puzzling and are sometimes very misleading, they are quite necessary for an understanding of the height of a crater wall, and a hundred other measurements of the various conformations of the surface. They simply require due consideration.

The moon is a dead world. The most minute investigation indicates that nothing could be more so. A dried up, wrinkled, wizened, scarred veteran, it bears the marks of terrible conflicts, of gigantic struggles. We know not its age. Did water once rush down those wondrous mountain gorges? Did the sea ripple and play about those towering capes Laplace and Heraclides and at times dash madly against those great precipices? We can only guess. Our fancy pictures, in the distant past, smiling vegetation, life, joy, and happiness in a world of glory. It is true there are some indications of this. But death came. Like a mummy it is to-day. Life departed, embalmed, naught remains but the shrunken, desiccated, cracked carcass. The beauty of life is gone. Its history, its experiences written in the shroud, are in mysterious hieroglyphics, of which man has been able to decipher but little. To-day no grass waves on the hillside. Not a single blade would give the weary traveler a welcome. No bird warbles his cheery song there. Not even the hated snake suns himself upon the many rocks. Not an insect flits about in quest of prey. Not a breath of air stirs. Not a sign of life appears anywhere. Inconceivable desolation!

Night comes. The sun sinks behind the lofty hills, and suddenly all is dark. No twilight softly intervenes. Cloudless the sky, devoid of air and moisture, no light is reflected or refracted. There can be no diffusion of sunlight under such conditions. Black night sits side by side with brilliant day wherever the rays of the sun are intercepted. Behind the jutting rock, beneath the ledge, within the cavern of broad entrance, it is night, though day reigns supreme with intense brightness all about.

It is quite a surprise to many to learn that the earth presents more light to the moon than it receives in return. Assuming that they possess the same reflective power, the surfaces compare as 27 to 2. Thus the earth should be credited with reflecting more than thirteen times as much light as its satellite. This light thrown upon the moon is known as "earthlight," and is in all respects similar to our moonlight. When the moon begins its monthly journey around the earth by passing between the sun and us, the earth is "full moon" to it, while that body presents the phase of "new moon" to us. Thus the greatest amount of "earthlight" reaches the dark portions of the moon at this time. It is this phenomenon which gives rise to that beautiful sight, "the old moon in the young moon's arms." As the age of the moon increases, this reflected light from the earth gradually lessens until there is none at full moon. Then as the moon nears the completion of its circuit the "earthlight" continues to increase in proportion.

While the moon is making this circuit of the earth 29½ of our days pass by. Yet she takes all this time to have but one day and one night. Day brings heat unbearable in its intensity. Scorching as the flames from the inferno, the sun pours his streams of fire hour after hour until the rocks fairly dance with molecular agitation. For fourteen days without a moment's relief this continues. Then with startling suddenness night appears. A temperature more than 200 degrees below zero assails all. Without the kindly protection of a cloud, stark naked as it were, and thrust into a temperature of glacial cold from such a bed of warmth, the results must be disastrous. Such extremes of heat and cold as these cannot but result in anything less than gigantic destruction. Great yawning chasms appear everywhere on the moon, some of which extend for hundreds of miles. Close scrutiny of these numerous cracks, a thousand of which have been charted, suggests to the observer the possibility of some slight extra disturbance resulting in a general disintegration of the whole satellite.

Seismic convulsions appear to have taken place at certain centers in the early history of the moon, producing remarkable results. The exterior of the molten mass had cooled sufficiently to form a crust, a brittle glass-like covering. A large number of the so-called craters had formed. Then with further cooling of the molten interior tremendous expulsive force was exerted, bursting the outer shell and throwing out great radiating cracks in all directions, like spokes in a wheel. Lava then oozed up through these openings, in some cases but partly filling them, in others overflowing. Congealing and solidifying under different conditions from the remaining crust, this formation is quite distinctive in appearance, showing as bright streaks. The crater Tycho at the south pole is the center of the greatest system of these light streaks, and thus was at one time in the throes of a seismic disturbance of unparalleled magnitude. Some of the streaks from this center appear to encircle almost half the moon, thereby indicating the violence attendant upon this great shock.

In order to give to the eye the effect attained by telescopic observation, I took the liberties of the artist and departed from scale measurements in one respect. With 180 miles to the inch, a distance of 2 miles on the moon would be 1/90th of an inch on the model. This is less than the thickness of your business card. A lunar precipice of two miles height would be a very prominent object under proper lighting conditions, and be worthy of special attention. Yet an elevation of but 1/90th of an inch on the model would be merely the thickness of a coat of paint! Therefore the elevations were accentuated in order to produce to the eye a natural appearance, for the strict adherence to scale in this respect would create misconceptions. Careful comparison of photos of the real moon and the sculptured one, under approximately similar lighting, shows marked contrast. But this was a feature that was not in the least considered important. My aim was not to attain photographic similarity, but to convey to the eye under daylight conditions details apparent only on rare occasions with the telescope. The scientific gave place to the artistic. For such departure I plead merciful consideration from my scientific friends.

In the plaster casts made from the original, many of the finer details have been lost. As a light fall of snow on rough ground spreads a brilliant blanket, while leaving still the form of every stone and every hummock, so in the casting, the plaster obliterated the harshness of the model, softening all to a pleasing degree. A realistic telescopic appearance resulted, which in some respects compensated for the loss of details obtained only after much labor. By a careful application of a coat of paint of a bluish gray tint the maria, or seas, were given a sufficient contrast from the snow-white plaster mountains to form in all an ideal full moon.

A very interesting question appeared while calculating measurements, "What is the smallest possible discernible object on the moon? Could you see a man there? Would a big tree show?" The average human eye is credited with a power of appreciating an angle of about half a minute of arc. This, however, is quite unintelligible to most people. Let us simplify it. It means that you should see an object one inch in diameter at a distance of about five hundred and fifty five feet. This would indicate that a "beauty plaster" of one-eighth-inch diameter upon the fair cheek of the *debutante* should be visible at some sixty-nine feet. Applied to the moon, which averages in size thirty minutes of arc, the unaided eye is capable of discerning a spot measuring one sixtieth of her diameter, or 30 seconds. Now a linear mile on the moon corresponds to 0.87 of a second. Therefore a region one mile square must be magnified by artificial means to equal 30 seconds, that the eye may even perceive it as a point. The power required is evidently about thirty-four. Measurements show that a second of arc represents about two thousand yards on the moon. Thus we would have to magnify an object of that size thirty times to bring it to discernible proportions. Two hundred yards would require ten times this power, or 300. Consequently 20 yards would demand a magnifying power of 3,000! There must be a very fine atmosphere to admit of the use of a power of 500. One thousand power is quite the limit. Even this latter magnification would bring the moon to a distance of 240 miles, and no object under sixty yards could possibly be detected, if our theory is sound. It is quite evident that a man could not be seen. A big tree would not show. Aided by the most powerful telescope, and under conditions of magnification verging upon impracticability, it would be doubtful if an object less than one hundred yards in diameter would be discernible to the human eye as anything but a mere speck. With but one hundred miles separating you from a mountain and with ideal atmospheric conditions, judge what little your naked eye could determine of the details.

Melting Points in Commercial Brasses and Bronzes

As the result of tests made under the direction of the United States Bureau of Mines, the following table of the melting-points of commercial brasses and bronzes has been summarized:

Alloy.	Approximate Composition. Copper.	Zinc.	Tin.	Lead.	Melting point. C. deg.	F. deg.
Gun metal	88	2	10	..	995	1823
Leaded gun-metal....	85½	2	9½	3	980	1795
Red brass..	85	5	5	5	970	1780
Low grade red brass	82	10	3	5	980	1795
Leaded bronze	80	..	10	10	945	1735
Bronze with zinc...	85	5	10	..	980	1795
Half yellow, half red	75	20	2	3	920	1690
Cast yellow brass...	67	31	.	2	895	1645
Naval brass...	61½	37	1½	..	855	1570
Manganese bronze..	..	..	.	..	870	1600

The melting-point given is the "liquidus," or point where the alloy is completely molten. The tests are described in detail in Technical Paper No. 90.—*American Machinist.*

The Aeroplane in War*

Its Possibilities and Its Limitations

By Major W. S. Brancker, R.A.

The aeroplane is, as yet, untried in war; as although it has seen active service in Tripoli and in the Balkans, in neither of these countries were the conditions such as to afford much information concerning its possibilities. Hence their value in war and the methods of employment are only matters for conjecture. At the present time, however, armed airships and aeroplanes and weapons of offense and defense against aircraft are in existence, and therefore peace training will lack only the reality of war.

Of the many possible duties which can be performed by aeroplanes in war, the following are the most important: 1, Reconnaissance; 2, the destruction of hostile aircraft, both airships and aeroplanes; 3, the attack of troops on the ground and of material, such as airship sheds, oil tanks, magazines, etc.

1. *Reconnaissance.*—Reconnaissance is the principal duty of the aeroplane in war; it has been possible for the last two years, and will be the most important factor if war breaks out to-morrow. In this sphere, the aeroplane has come as an antidote to the growing difficulty of reconnaissance in modern warfare. Sound war plans are easily made if the enemy's forces and probable intentions are known, but the greater accuracy of long range rifle and gun-fire, increased numbers and more extended formation of troops, and the use of smokeless powder, have thickened the fog of war and made it most difficult and dangerous for cavalry to reconnoiter an enemy's position. But, given good conditions, a great deal of information can be gleaned of the enemy's dispositions, particularly during the earlier phases of a campaign, when the troops are in close formations; and an aeroplane flying at 4,000 feet should be able to bring in information ten times faster and more definite than that which a division of cavalry might normally obtain after a day's fighting.

There are, however, various adverse factors with which aerial services have to compete, and that tend to prevent any approach to infallibility in the results obtained. Among these are:

(*a*) Imperfect observation and hostile subterfuges; (*b*) climatic conditions; (*c*) difficulties of maintenance; (*d*) anti-aircraft weapons on the ground; and (*e*) fighting in the air.

(*a*) *Imperfect Observations.*—The art of accurate observation from an aeroplane is much more difficult, and requires far more training than does the art of flying. Both pilot and observer must be able to read and understand a map just as quickly and as easily as they can a book, and at any instant during a cross-country flight they should know exactly where they were. Beyond this, the observer (or in a single-seater, the pilot) must be able to pick up troops on the ground, estimate what they are, their numbers, and mark their precise position on the map. He may have to do this in a rough wind and in the midst of fleeting clouds; and on landing, write a clear and intelligible report of what he has seen. It is not therefore surprising that the results of aerial reconnaissance are sometimes inaccurate and misleading, and this weakness will be intensified by subterfuges undertaken by the enemy for the express purpose of deceiving the observer, such as by stringing out small columns along roads to represent large ones while the mass of the troops are kept hidden in woods and villages; dummy trenches may be constructed while the real trenches are hidden; guns may be made to look like bivouac shelters, bushes, or country carts, etc.

The best guarantee that aerial reconnaissance will overcome these difficulties lies in the careful training and wide experience of the observers, and in the possession of sufficient numbers of aeroplanes to enable doubtful information to be checked and corrected without delay. Assistance to full and accurate observation may be obtained by the use of aeroplanes which can fly slowly and have a good field of view, although these are somewhat handicapped in strong winds.

(*b*) *Climatic Conditions.*—Nature is the greatest enemy against reconnaissance at the moment; her weapons are wind, rain, cloud, and darkness. Wind is gradually being conquered, as aeroplanes, traveling at from 60 to 70 miles per hour, have actually been blown backward by winds they have encountered. But the great drawback to the wind is the reduced radius of action of the aeroplane. As regards the progress made against the effects of rain, the impact of the drops of rain on the eyes of the pilot blind him; but in the latest types of machine the seats were screened, so that this difficulty in flying had been largely overcome, and observation is practicable at low altitudes.

High clouds (that is, those from 3,000 feet high and upward) do not hinder observation, but rather assist it, by affording a sheltering screen to the aeroplane, if necessary, and at this altitude a pilot is comparatively safe from infantry fire; but clouds at lower elevations force the observer to come within the effective range of rifle fire from the ground. This can be remedied by the development of the armored aeroplane. Fog, however, will always presumably defeat aerial reconnaissance, just as it defeats reconnaissance on the ground. Flying in darkness is not much indulged in at present, because engines are not sufficiently reliable to eliminate the possibility of a forced landing, and a forced landing on an unknown ground usually means a bad smash, but with the really reliable engine, night flying will become universally practised.

Hence, to compete with climatic conditions there are two important requirements: (I) Reliable engines and (II) high speed. As regards speed, a machine that is fast in the air is always difficult to land, even though it can land slowly in the hands of a good pilot where the country is open. The antidote for this lies in the use of air brakes for coming down steeply, and of land brakes for pulling up quickly after touching the ground. Experiments in both are proceeding, and successful land brakes actually exist in some machines. High speed has, however, another disadvantage, namely, in still air it is much more difficult to observe accurately than from a comparatively slow aeroplane, and though it may be perfectly easy to see every detail of the country and the troops moving in it, the eye, the brain, and the hand are not quick enough to gage accurately where those troops are on the map, and to record the fact in a note-book before the aeroplane is miles further on, and some, perhaps important, detail has been completely missed. Variable speed will get over this difficulty.

(*c*) *Difficulties of maintenance* are sometimes lost sight of. The aeroplane and its engine are both fragile and delicate. A good average pilot may fly, day after day, round an aerodrome and make many landings without even straining his machine; but in war the pilot must fly in any weather to obtain information, and land on almost any ground to deliver it. The result will be numerous breakages and strains, all of which take time and skill to repair, and which demand the provision of large quantities of spare parts wherever required on the theater of war. The difficulty of supply of spare parts will be increased in proportion to the number of different types of aeroplanes employed. Similar remarks apply to the engines, which, in addition, require thorough overhaul after a comparatively short period at work. Portable tents will also have to be carried for housing machines upon the ground to prevent serious deterioration in the flying qualities of the machines. All this points to the fact that only a small proportion of the aeroplanes in the field will be fit to take the air at any given moment.

The cures for this weakness are various, and can all be applied simultaneously. 1, Increased durability in construction; 2, reduction in the number of types of aeroplanes and engines employed; 3, the introduction of folding aeroplanes which can be more readily housed than the prevailing type; 4, a really experienced personnel.

(*d*) *Anti-aircraft Weapons on the Ground.*—All nations are endeavoring to evolve anti-aircraft guns, both fixed and mobile; but at the moment they do not exist for employment with a mobile army in the field, and for reconnaissance purposes an aeroplane is safe at 3,000 feet from rifle fire, and at 4,000 feet from gun fire. There are great inherent difficulties in firing at aeroplanes, principally in regard to range, speed, and direction of the machine; while it is almost impossible to recognize whether it is friendly or hostile, although attempts were being made to help to differentiate between them.

(*e*) *Fighting in the Air.*—It is obvious that if hostile aeroplanes are armed with a weapon which can be used against the purely reconnaissance machine, the information brought in by the latter will, very likely, be greatly depreciated in value and in volume, and may not come in at all, and that to combat the armed aeroplane it is necessary to pit other armed aircraft against it.

Aeroplanes will not entirely relieve the cavalry of reconnaissance work, for cavalry reconnaissance succeeds where aeroplane reconnaissance fails, as cavalry can distinguish between friends and hostile troops, can discern the *morale* and physical condition of the enemy; it can keep in touch with any particular body of the enemy, and can offer opposition to its advance. The leader of the future will employ his aeroplanes and his cavalry so that one supplements the other, and the employment of the aeroplane in the initial stages of a campaign will enable a commander-in-chief to hold his cavalry back and save them much long and fruitless work, thus keeping them fresh for fighting when the main armies begin to close. The aeroplane will also enable the effect of artillery fire to be observed, thereby solving a difficulty which has been growing more and more acute during recent times; while intercommunication between widely separated forces will also be readily possible with any aeroplane suitable for reconnaissance.

All that has been claimed so far has been actually accomplished in peace and could be accomplished in war, while the suggested improvements and developments are practical possibilities, and are actually under experiment at the present moment.

2. *The Destruction of the Enemy's Aircraft.*—It has already been proved possible to fire a rifle, a machine gun, and even a 1-pounder gun from an aeroplane with fair accuracy, and it therefore seems logical that if two rival forces are equipped with aircraft, these aircraft must fight in order to maintain for themselves the advantage of being able to reconnoiter. The aeroplane of the immediate future will be armed, but the additional weight and strength involved entails loss both of speed and climbing power; so that, at the present, the armed aeroplane must be somewhat inferior in performance to an unarmed one, other things being equal. From an offensive point of view, an aeroplane may attack hostile (*a*) airship, (*b*) aeroplanes, and (*c*) aircraft on the ground. The average aeroplane is faster than the average airship, and therefore fighting is sure to occur so long as aeroplane pilots are determined to attack the airship. The aeroplane can fly faster, climb higher, and is easier to maneuver than the airship, while the latter can climb faster, and provides a steadier platform for a heavier armament than the former. It seems probable that airships will try to keep aeroplanes at a distance by virtue of their power to deliver more accurate fire, while the aeroplanes will endeavor to close in order to make use of their maneuvering power and to obviate the comparative inaccuracy of their fire. It may prove necessary to employ three or four aeroplanes, armed with machine guns, light guns, or bombs, for the attack of one airship. There is also the possibility of the fast aeroplane's catching and ramming or driving through the airship. This would be desperate work, but the destruction of two or three airships in this way would have a very great moral effect on the remainder. The combat between two aeroplanes is more difficult to imagine. If each was determined to destroy the other, the pilots presumably would maneuver so as to prevent the opponent using his weapon to the best advantage, while he gave his own companion the free use of his. If one aeroplane tries to avoid the other, then speed would be the determining factor as to whether they come to grips or not; but the pilot who decides to flee will, in doing so, present the best possible target to the pursuer. As has been stated, other things being equal, an armed aeroplane will always be less efficient in speed and climbing power than a similar machine not intended for the carriage of weapons, and therefore it will be difficult for the former to catch the latter, so it may be necessary to allot a definite area to an armed aeroplane, over which it would cruise and drive away any hostile scout that came into its zone. With such a scheme, encounters would be fairly frequent, and it may prove necessary to obtain command of the air before aerial reconnaissance is resorted to.

Aeroplanes and airships on the ground and their shelters can be seen from a great distance, and offer a very fair and defenseless target for attack; and the sudden attack of three or four aeroplanes provided with bombs and flying low might cause great damage to both, against which anti-aircraft guns would probably have to be employed.

3. *The Attack of Troops, Ships, and Important Buildings.*—At present it is unlikely that many aeroplanes can be used for the attack of troops on the ground.

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* The tenth of the series of special lectures arranged by the Military Education Committee under the authority of the Senate of the University of London.

Until fighting in the air had come to an end, and until all necessary reconnaissance had been completed, it would hardly be sound to devote much energy to such an object, while the damage done would probably be too small to justify the risk of venturing within decisive rifle range. On the other hand, at the end of a hard fought action, *if* any armed aeroplanes were still available, which is doubtful, they would certainly assist in completing the demoralization of a beaten army. The attack of big guns, magazines, and oil tanks will, however, be a part of an aeroplane's duties in the attack of a fortress.

It is impossible to include all the desirable qualities in one type of aeroplane and, at present, it is desired to confine the requirements of the army to five types, which are as follows:

(I) The high-speed single-seater scout of exceptional climbing powers for long range reconnaissance in any wind, and of such an efficiency as to be able to escape from any type of fighting machine which it may be possible to produce at present.

(II) A speedy two-seater reconnaissance machine suitable for deliberate long range reconnaissance and capable of carrying an observer and a wireless installation. Such a type could also be used for bomb dropping.

(III) A two-seater reconnaissance aeroplane having an exceptionally good field of view and the ability to land anywhere, which will be especially suited for short range reconnaissance during the actual battle and for observation of artillery fire.

(IV and V) Finally, two fighting machines, one to carry a machine gun and the other a light gun, firing shell, both of them tentative, but both well within the range of possibility at the present moment.

The ideal would be to standardize in each of these types; but even this is impossible, as every really promising design must be given a trial, and every promising constructor must be given work.

It seems that the use of the aeroplane for reconnaissance cannot fail to hasten the progress of operations, at all events between two determined opponents who understand the value of the offensive. Fighting in the air will probably demand a higher standard of *morale* throughout those engaged in it than any other feature in war, and an aerial service which is lacking in this respect will speedily vanish from the air in the face of opponents who have it.

The aeroplane has depended almost entirely on its warlike capabilities for its development, and all those who object to a large expenditure on so warlike a service should remember that every penny which is put into military aviation is not only providing an insurance against war, but is developing the luxurious flying machine of the future.

The geographical position of any nation will no longer offer the same advantages, or disadvantages, as it does to-day. From now onward, the struggle for aerial supremacy, be it commercial or military, will go on irresistibly; new developments are following one another in hot haste, and a great nation like our own will only be able to keep her place in the race by the unflinching expenditure of money and sacrifice of life.

The Action of the Control Organs of an Aeroplane in critical attitudes

THE two main problems which confront the aeroplane constructors are:

First. To design machines capable of carrying their load with a small expenditure of power, while at the same time having motors capable of developing two or three times, or even four or five times, as much power as is required for ordinary flight. These qualities are obtained by reducing the passive head resistance to a minimum, by refining the lines of the machine generally, and by giving the wings the best possible section.

Second. To bring out machines possessing a good stability in the air, and having control organs which are effective in all conceivable positions of the machine.

In this lecture I propose to deal with the study of the forces to which aeroplanes are subject, and the way of modifying the points of application of these forces by means of rudders, elevators, and *ailerons*, in order to right a machine which has been thrown out of its normal attitude of flight.

The frequent accidents tend to give one the impression that the equilibrium of an aeroplane is very precarious, and that once the machine gets past certain attitudes the pilot is unable to control it and thus prevent a fatal accident. Is it true that these critical attitudes are so dangerous? Evidently not, for aviators like Pegoud, Chevillard, Garros, etc., have proved by actual experience that a machine can occupy all conceivable positions and yet be righted with ease. The critical conditions are: 1. Too low speeds; 2, too high speeds; 3, sideslips and dives.

1. *Too Low Speeds.*—When an aeroplane loses its speed the reaction of the air on its planes is insufficient to support it in spite of the increased angle of incidence. For angles of incidence of from 15 degrees the lifting forces do not increase with the angle of incidence, and for angles from 20 degrees they decrease. Generally when an aeroplane loses speed it turns over either to the right or to the left. This is what is called a sideslip. If the pilot tries to right his machine by warping he will only increase the sideslip, and if his motor is failing he can only right the machine by diving it until it has regained its flying speed. If the motor possesses great reserve power it is possible to right the machine before the sideslip has become very pronounced. While this sideslip is, of course, dangerous when the machine is close to the ground, there is little or no danger when it is flying at an altitude sufficiently high to allow of regaining its speed by a dive. Besides, a machine with a proper *empennage* will not lose its speed unless the pilot wishes it to do so, and it does not seem necessary to fit an automatic control organ for the purpose of helping the pilot. It is, however, always advisable to fit speed indicators which will keep the pilot informed as to the behavior of his machine.

2. *Too High Speeds.*—It is generally admitted that the conditions of too high speeds present a certain danger. It has been said that aeroplanes flying at very small angles of incidence may, by a sudden longitudinal swerve or dive, receive a sudden pressure on top of their wings, and thus losing all sustentation, they fall.

The point to be studied with regard to high speeds is: How do the points of application of the forces to which an aeroplane is subject vary for possible variations in the angle of incidence during these high speeds? Experiments with scale models in the laboratories are very instructive, and it has been possible to verify that certain machines with too deeply cambered wings, or with insufficient *empennage* or badly adjusted, may become unstable when flying with very small angles of incidence. It should be remembered that for a cambered plane the center of application of the resultant of the forces acting on it travels backward, progressively, as the angle of incidence decreases, and that for very small angles of incidence the travel of these centers is considerable.

At the Eiffel laboratory a series of experiments have been commenced with scale models of aeroplanes flying with the most critical angles of incidence by placing them in the air current, and the interesting results obtained lead to the conclusion that it is easy to design machines which the pilot can always right by means of the control organs.

3. *Sideslips and Dives.*—A fall started either by side-slipping or stalling always terminates, if the machine has a suitable *empennage*, in a vertical nose dive. The study of forces, acting on scale models, shows that even from this attitude the machine may be righted by suitably operating the control organs. The most important thing to observe is that the pilot is not thrown out of his seat, and that, thanks to an efficient safety belt, he is able to operate his controls, whatever the attitude of his machine.

Suppose that a machine through some cause or other is making a nose dive, and that the pilot is strapped in his seat. He finds that he is unable to right the machine by operating his elevator—such a contingency often occurs, and many pilots have experienced it. The thing to do in a case like that is to push the rudder over as far as it will go, for instance, to the right, in order to make the machine turn to the right with relation to its vertical path of flight, and at the same time warp the wings so as to make the machine revolve around its longitudinal axis after the fashion of the hands of a clock. The aeroplane will then right itself by describing a spiral similar to those favored by certain pilots in their exhibition flying.

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[*] An abbreviated translation, made by *Flight*, of a lecture by M. Louis Bréguet to the Société Française de Navigation Aérienne.

The Swiss National Exhibition at Berne

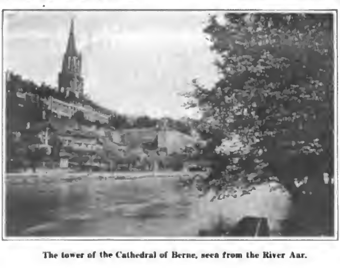
The Year 1914 Marks the Fourth Exposition of This Kind in History

THE Swiss National Exhibition which is held in Berne, the country's beautiful capital, up to October 15th next, had a brilliant opening on May 15th, and it is anticipated that it will be the rendezvous of thousands of representatives from all lands and all nations.

Switzerland has only arranged two national exhibitions so far: one at Zürich in 1883 and another at Geneva in 1896. While the progress and development achieved during the interval between those two exhibitions are pronounced as altogether wonderful for a country with limited resources, the reports about this present exhibition indicate that it will be a revelation even to those who know the country intimately.

The exhibition contains seven main sections:

1. Agriculture and Mining.



The tower of the Cathedral of Berne, seen from the River Aar.

The Historical Museum at Berne.

Military Pavilion and International Bureau in the Neufeld section of the exhibition grounds.

The principal restaurant of the exhibition, "Studerstein," on the left, and the building Hospes on the right.

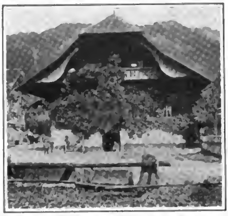
2. Trades, Industries and Engineering.
3. Commerce and Traffic, including Sports and Touring.
4. Political Economy and Public Welfare.
5. National Defence.
6. Arts and Sciences.
7. International Bureaus.

The site of the exhibition is on an elevated plateau to the northwest of Berne, on the borders of the Bremgarten Forest. It is open to the east and south, and commands from every part a wonderful view of the Bernese Oberland. The area of the exhibition grounds measures some 500,000 square meters, of which 135,000 are covered with the buildings, while the remainder of the site is laid out in such a way as to harmonize with the neighboring forest.

An electric railway circulates over the whole of the exhibition grounds, which are divided into three fields: The Neufeld, the Mittelfeld, and the Viererfeld.

The Neufeld is the largest section of the exhibition grounds, and, in a technical point of view, the most interesting, for here we find: Architecture and Decorative Art, Textile Industry, Watches, Precious Stones and Metals, Musical Instruments, Paper Industry and Graphic Art, Chemical Products, National Defence, Education, Administration, Hygienics, International Associations, Gas and Water Service, Sewerage and Town Cleaning, Means of Transportation, Public Conveyances, Civil Engineering and Machinery.

A very comprehensive exhibition covering Railway Rolling Stock, with the Swiss Federal Railroads as the largest exhibitors, of course, is already exciting the interest of railroad men. Among other exhibits is the first locomotive (now about seventy years old) ever used in Switzerland, side by side with the newest and most modern locomotives employed for express trains on the St. Gothard line. The new Lötschberg Railway show their 2,500 horse-power electric engines, which, being the most powerful of the kind in the world, will prove of utmost interest to technicians. The exhibits include also special invalid railway carriages, which can be used for international traffic; rotary snow ploughs, mail and luggage vans, also vans for the transport of wine, beer and meat, and other perishable articles or goods which must be kept cool.



A typical Bernese Châlet at Interlaken.

A passageway leads from this exhibition to the Machinery Hall, the most conspicuous building on the whole exhibition grounds. It covers about 18,000 square yards and is the largest existing iron construction in Europe.

In this part of the exhibition it is possible to realize the use to which the water-power of Switzerland is now systematically put. Some of the Swiss engine and machinery makers are known throughout the world, notably those of Baden, Oerlikon near Zürich, Winterthur and Schaffhausen, and all are showing interesting machinery here at work, in charge of skilled mechanics. The necessary electric power is furnished in the building.

The Machinery Hall has two galleries reached by electric elevators. The machinery exhibited includes steam and water turbines, pumps and mechanism used in the preparation of food products, also a Diesel oil engine. There are two main divisions in the Hall, one for high-current and the other for low-current machinery. The exhibits of the Association of Swiss Electro Technicians and of the Swiss Electricity Works are under the same roof, Switzerland being one of the foremost countries in the application and knowledge of electricity.

Wireless Telegraphy[*]

A Comprehensive Review of the Various Systems

By H. Fothergill

SPARK SYSTEMS.

Damped Electric Waves.—The simplest way of signaling is by means of damped electromagnetic waves, and these can be easily produced by a spark coil or transformer having its two high-tension terminals connected respectively with an aerial wire and with the earth, a spark gap being placed between the connections in the manner illustrated diagrammatically in Fig. 1. The current through the primary circuit of the coil is controlled by the key *K*, so that by holding down the key for long or short periods, long and short series of waves can be transmitted corresponding to letters which are represented by the dots and dashes of the Morse code. The high-tension current charges the aerial wire until the charge increases to such an extent that it sparks across the gap, and the aerial discharges itself to earth, the strain being broken down and a wave given off. The aerial, however, not only discharges itself, but, as it were, overdischarges itself. The current rushes back again over the spark gap and charges the aerial. This oscillatory flow backward and forward between the aerial and the earth occurs a number of times until the energy is dissipated partly by radiation and partly by resistance and other losses, and insufficient remains to maintain the spark across the gap. The coil then charges the aerial again, and the same action is repeated.

The charge which can be given to an aerial wire is limited by the capacity of the wire, which is usually very small. Moreover, the aerial wire in Fig. 1 not only forms the charging circuit, but the radiating circuit, and the arrangement results in the production of highly damped oscillations, which soon die away. A good oscillatory circuit should be a bad radiating circuit, so that the charge will continue to oscillate for some considerable time before being wholly dissipated. To meet this requirement the oscillatory circuit is constructed by the Marconi Company of London and by the Telefunken Company of Berlin, as a separate circuit, and is coupled to the radiating circuit wherein slightly damped oscillations are produced, and which, when impinging on a distant receiver, create a cumulative effect that is very desirable.

The Marconi System.—Fig. 2 shows diagrammatically a popular arrangement of the Marconi system. The electric current is generated by an alternator and passed through the primary coil of a low-frequency, iron core transformer by which its voltage is increased to that required for charging the condenser in the oscillatory circuit. "The low-frequency or alternating circuit includes additional inductance either in the transformer primary or secondary circuit adjusted so that the natural period of the alternator-transformer-condenser circuit corresponds with the alternator frequency; this adjustment is provided so that the condenser charging current may be about zero value when the condenser is about to discharge." The oscillatory circuit comprises a condenser, the primary coil of a high-frequency air-core transformer, a variable inductance for altering the wave-length, and a disk discharger by which the condenser is discharged. This discharger consists of a revolving toothed wheel placed between two stationary teeth, so that every time a pair of teeth comes opposite the stationary teeth the current sparks across and the condenser is discharged. The time of charge corresponds to a half cycle of the alternator, and to the period elapsing during which there are no moving teeth opposite the two stationary teeth, the voltage or pressure to which the condenser can be charged depending on the amount of energy which can be stored in the condenser during the time of charge.

The radiating circuit in Fig. 2 includes the secondary coil of the high-frequency transformer by which energy is absorbed from the oscillatory circuit and radiated from the aerial wire in the form of electromagnetic waves. A variable inductance is included in the radiating circuit for the purpose of varying the wave-length so that it may be brought into tune with the oscillatory circuit. Suppose it is desired to send a signal. The sending key is pressed down, and thus allows the current from the alternator to flow through the primary coil of the low-frequency transformer, which induces a high-voltage current in the secondary coil. This high-pressure current passes round the circuit and charges the condenser, which is periodically discharged, say, 450 times per second, by the revolving toothed wheel. Each condenser discharge produces a group of electric oscillations in a manner similar to that described with reference to the discharge across the spark gap in Fig. 1. These oscillations, by passing through the high-frequency transformer, induce oscillations in the radiating circuit which alternately charge the aerial wire in opposite directions, and in so doing produce electromagnetic waves which are propagated outward in all directions over the surface of the earth. It will be noted that choking coils are placed between the low-frequency transformer and the oscillatory circuit. These are inserted for the purpose of preventing the high-frequency oscillations from passing into the low-frequency transformer and doing possible damage.

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[*] Abstract published in *The Engineer* of paper read before the Northeast Coast Institution of Engineers and Shipbuilders.

Telefunken System.—This system is illustrated diagrammatically in Fig. 3, from which it will be seen that it is similar to the Marconi system; the two companies, however, agreed upon terms which avoided litigation. The principal differences between the two systems are the method of discharging the condenser and the method of producing oscillations in the radiating circuit. The discharger, which is illustrated diagrammatically in section in Fig. 4, consists of circular plates of copper separated from each other by mica distance-pieces of about 2 millimeters in thickness. The spark forms at any point on the flat surface of the plates; it is then forced toward the periphery in a radial direction by the electromagnetic field, and is eventually extinguished on its path by a circular groove which the spark cannot bridge. Between each pair of plates is a large disk of thin copper, which is effective in radiating the heat generated by the spark. Short-circuiting plugs, which can be inserted between the copper disks, are provided in order to short-circuit as many gaps as may not be required. The quenched spark discharge may thus be adjusted to suit the voltage, and consequently permit of variations in the power utilized. For example, if small power is required a number of gaps will be short-circuited, and the alternator voltage reduced; if full power is required, all the gaps will be opened and the alternator voltage raised to correspond with the number of gaps. It will thus be seen that by connecting a suitable number of gaps in series and adjusting the voltage, it is possible to keep the energy per gap from exceeding a certain value, and thus avoid overheating, which would prevent the quenching of the spark. Since the energy transmitted varies as the square of the number of spark gaps, the regulation by short-circuiting covers a wide range. Thus, if there are ten gaps and nine are cut out, the maximum energy can be reduced to 1 per cent. The pressure per gap is approximately 1,200 volts, so that if ten gaps are in use the charge given to the condenser will reach a pressure of approximately 12,000 volts before discharging across the gap and round the oscillating circuit in which it oscillates. It will be noticed that the radiating circuit is not indirectly coupled to the oscillatory circuit, as in the Marconi system, but is directly coupled by what may be called an auto-transformer, consisting of a copper helix, one part of which is included in the oscillatory circuit, the other part forming a portion of the aerial or radiating circuit.

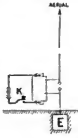

Fig. 1.—Plain aerial.

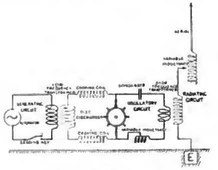

Fig. 2.—Marconi system.

The action of a coupled circuit transmitter, whether on the Marconi or Telefunken system, is less simple than would appear at first sight. It might seem natural to suppose that the oscillatory circuit is unaffected by the radiating circuit, but this would be an incorrect assumption, because, just as the currents flowing to and fro in the oscillatory circuit induce similar oscillations in the radiating circuit, so do the induced currents oscillating in the radiating circuit tend to react on the oscillatory circuit. Thus when the oscillatory circuit has given up its energy to the radiating circuit, the latter circuit rebounds, as it were, and starts giving back some of its energy to the oscillatory circuit. One circuit reacts on the other till the oscillations induced alternatively in each circuit die away or are drowned by the violent oscillations which are being frequently produced with maximum amplitude by the condenser discharges. This action of the energy swaying backward and forward from one circuit to the other is illustrated graphically by Fig. 5. The upper curve represents the oscillatory circuit and the lower curve the radiating circuit. It will be seen that the oscillatory circuit commences with a maximum amplitude which corresponds with the moment of discharge of the condenser, and that the oscillations are absorbed by the radiating circuit, in which the induced oscillations are of maximum amplitude when the whole of the energy has been absorbed by it from the oscillatory circuit. The radiating circuit then reacts on the oscillatory circuit, with the result that instead of the whole of the energy remaining in the radiating circuit and being dissipated in the form of electromagnetic waves, it is partly wasted in uselessly exciting the oscillatory circuit. This exchange of energy continues until the whole of the energy is dissipated or radiated from the aerial wire. The entire effect extends over only a fraction of a second, and is equivalent to the time during which each spark occurs at the discharger.

If a Marconi revolving disk discharger is suitably designed and run at a predetermined speed, the period during which two moving teeth are passing the two stationary teeth, is equal to the period during which the whole of the energy is originally transferred to the radiating circuit; and as the spark is then extinguished, the teeth having moved on, it is impossible for the energy in the radiating circuit to flow back into the oscillatory circuit. The result is that the oscillations continue in the radiating circuit with a steadily decreasing amplitude. During this time the condenser is again being charged ready for discharge by the next two moving teeth, which pass the two stationary teeth, when a new series of oscillations will be induced in the radiating circuit. This true effect is obtained with disks running with high peripheral speed, and working with long waves and loose coupling, as the disk may then be arranged to cut off a discharge or spark before any material part of the energy communicated to the aerial is returned to the oscillatory circuit.

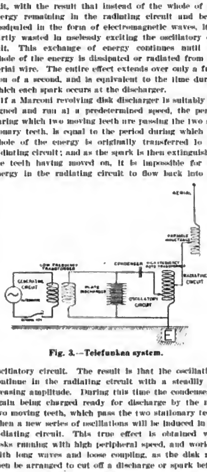

Fig. 3.—Telefunken system.

Undamped or Continuous Oscillations.—An undamped or continuous oscillation is one which oscillates continuously with the same amplitude. At present there are two notable systems which produce undamped or continuous waves; they are the Goldschmidt and Poulsen.

Goldschmidt System.—In theory this system approaches very closely to the ideal; but so far it has been unfeasible to carry out in practice what appears so desirable in theory. Theoretically, the system consists of an alternator which produces an alternating current having a very high frequency, the frequency corresponding to the frequency of the oscillations that it is desired to produce in the aerial wire. To understand why such a system is impracticable for commercial use, that is, for from ship to shore signaling, it will be necessary to consider the construction of an alternator. It should first be stated, however, that, according to international law, the wave length used on ship stations must measure either 300 meters or 600 meters, the ability to radiate a 300-meter wave being compulsory, but the use of a 600-meter wave is optional. Therefore, in order to be suitable for use on shipboard the alternator must be able to produce oscillations which will give a 300-meter wave.

Now, it is easy to show that a 300-meter wave corresponds to 1,000,000 oscillations per second, and therefore the frequency of the alternations in the current produced by the alternator must equal 1,000,000 per second. Usually the frequency of an alternator depends on the revolutions per minute and the number of magnetic poles. Even supposing the periphery of its moving part were divided into 100 poles, which is a large number, the speed would need to be 1,200,000 revolutions per minute in order to obtain a frequency of 1,000,000 per second. This speed is, of course, obviously impossible. However, according to a special arrangement of Goldschmidt's, the magnetic field of his alternator is rotating, not mechanically, but electrically, while at the same time the armature is rotated mechanically in the field in the opposite direction. The result of this is the production of a frequency depending on the sum of the rates of rotation of the magnetic field and of the armature; and current at this higher frequency is carried back to the field and produces a more rapidly rotating field than the first. To this, again, is added the frequency produced by the rotation of the armature. This process is repeated several times until the required high frequency is reached. In theory it is feasible, but in practice the complications and loss of energy at each step are so great that the inventor has not yet exceeded a frequency of 40,000 per second, which is a long way short of 1,000,000, the frequency required for the 300-meter wave. The system is therefore unsuitable for short wave-lengths, and is not likely to come into use for from ship to shore signaling.

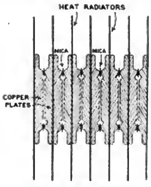

Fig. 4.—Discharger.

Let us consider, then, whether or not it is possible to use such an apparatus for long wave-lengths, such as are used in high-power long-distance stations. The wave-length corresponding to a frequency of 40,000 per second would be 7,500 meters in length, a wave-length which has been frequently used, and therefore the system could be employed for long distance signaling, but apparently from the negotiations between the Postmaster-General and the Goldschmidt Company in Germany, the system has not yet proved itself reliable. From the information available it seems as if Goldschmidt proposes to use for transatlantic signaling a 500 horse-power steam engine driving two dynamos of nearly 200 horse-power each, the armatures of these machines being connected to a motor that drives the high-frequency alternator, the rotating part of which has no fewer than 384 poles. It would seem that the general plan adopted in damped wave systems of driving the whole of the moving plant direct on one shaft from a steam turbine is more simple and desirable.

Poulsen System.—Nearly fourteen years ago it was shown by Mr. W. Duddell, the past president of the Institute of Electrical Engineers, that when an electric arc between two solid carbon rods, as in a street arc lamp, is shunted with a condenser and inductance in series, electric oscillations are set up in the condenser circuit. In 1903 Valdemar Poulsen of Copenhagen described important improvements in this method of creating electric oscillations. He produced an electric arc between a carbon rod and a copper rod which was kept cool by water circulating within it (see Fig. 6). The arc was at the same time surrounded by an atmosphere of hydrogen or a hydrocarbon gas or vapor, and crossed transversely by a strong magnetic field. This arc formed part of an oscillatory circuit, including a condenser and a primary coil of a high-frequency transformer, the secondary of which formed part of the radiating circuit.

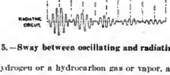

Fig. 5.—Sway between oscillating and radiating circuits.

It is characteristic of an electric arc that as the current increases the potential difference of the carbons decreases, or, in other words, the more current that is passed through the arc the less is the pressure difference between the carbons. Now let it be supposed that the arc be burning steadily, and the oscillatory circuit is applied to it, electricity rushes into the condenser, and while it is being charged the current through the arc is diminished. The pressure difference across the arc is therefore increased, and the tendency is to charge the condenser still further. When the condenser is fully charged the arc current again slightly increases, and thus causes a reduction in the pressure difference across the arc. This reduction in pressure allows the condenser to discharge itself across the arc, thus increasing the arc until the maximum current is reached, when the cycle recommences. These rapid condenser discharges produce oscillations in the radiating circuit, which are sustained by the condenser alternately drawing current from the arc and then giving it back again at the moment of discharge, the result being the production and radiation of persistent or undamped waves.

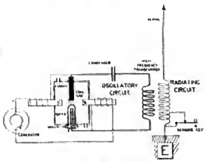

Fig. 6.—Poulsen system.

If an arc of this description could be constructed of one in size that it could deal with sufficient energy for long-distance signaling, and provided the arc could be maintained in a stable condition, then there seems to be no reason why such a system should not become popular, even though its efficiency is very low. But the arc does not remain steady, and it would seem unreasonable to expect it to do so. Its instability is caused by the carbon electrode, which is continually burning away, and this tends to keep the actual length of the arc in a state of variation which cannot be avoided even by the feeding mechanism provided. This variation in the arc results in a variation in the current flowing across it, which also means a variation in the charge given to the condenser, and a consequent variation in the strength of the waves emitted. The seriousness of a weakening in the waves transmitted will become at once apparent when it is realized that if the strength of the waves is suddenly decreased, as the result of a variation in the arc, the reception of the signals at the receiving station might be rendered inaudible, and probably the whole of the message would need to be repeated. The most serious objection to the Poulsen system is not, perhaps, the weakness of radiation, but the variations in the length of the waves transmitted, which result in the signals disappearing at the receiving station owing to the transmitter getting out of tune, or result in the signals inverting: that is, spaces coming through as signals instead of the dots and dashes, owing to the spacing signals getting in tune with the receiver.

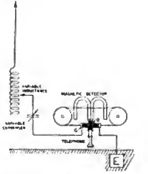

Fig. 7.—Simple receiving circuit with magnetic detector.

RECEIVING ELECTROMAGNETIC WAVES.

An aerial wire absorbs some of the energy of electromagnetic radiation falling upon it, and it absorbs best radiation of that kind and wave-length which it would itself emit if set in oscillation, and absorbs it most readily when arriving in the direction in which it would itself radiate most strongly. The length of an electromagnetic wave depends on the oscillation constant of the circuit, and the oscillation constant depends on the capacity of the condenser and the quantity of inductance in the circuit. Therefore all receiving stations should have embodied in their circuit a variable inductance and a variable condenser, whereby the circuit may be tuned to receive the waves radiated from the transmitting station.

The oscillations produced in a receiving circuit by the waves impinging on the aerial wire to which it is connected are not directly appreciable by our senses, and their existence can only be ascertained by the employment of detectors. When an aerial wire is to be used for receiving it may be connected directly to a circuit containing an oscillation detector, or inductively coupled to a circuit in which the detector is placed. The former and simpler method is shown in Fig. 7. Waves from the transmitting station impinge on the aerial wire, and if the variable inductance and condenser are suitably adjusted so that the wave-length of the receiving circuit corresponds with the wave-length of the transmitting circuit, then energy will be absorbed by the aerial wire and electric oscillations set up, which swing backward and forward between the aerial wire and the earth. Inserted in the circuit is a detector, which in the arrangement illustrated is of the magnetic type. This instrument is largely used by the Marconi Company, and comprises an iron band rotating in a magnetic field so as to carry the iron through a cycle of magnetic changes. When electric oscillations pass through the primary coil wound round the band, the change of the magnetic state of the iron generates an induced current in the secondary coil, and hence a current and a sound in the telephone receiver.

Fig. 8 shows an example of a receiving circuit which is inductively coupled to the detector circuit by two coils *A* and *B* so arranged that one moves axially within the other, whereby the distance between the coils can be varied. The great advantage of a coupled circuit is the ability to eliminate waves of slightly different wave-length, and thus promote sharpness in tuning, which is such a very desirable feature. For example, suppose we desire to pick out a distinctive station among several which may be signaling, we would first bring the coils *A* and *B* close together or slide one within the other so as to couple the two circuits tightly, and then tune the detector circuit by varying the condenser and inductance until the value of its oscillation constant approaches that of the receiving circuit, when we will hear the signals intended for us. If, however, these signals are "jammed" by signals from other stations, then the coils *A* and *B* are separated from each other and the circuits finely tuned by careful adjustment of the condensers and inductances, so that only that wave which will set the receiving circuit oscillating most violently will induce oscillations in the detector circuit. The undesired waves, which may be of slightly different frequency, will not produce oscillations in the receiving circuit of a strength sufficient to reach across the distance between the two coils *A* and *B*, and induce forced oscillations in the detector circuit.

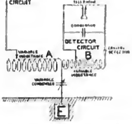

Fig. 8.—Telefunken inductively coupled circuit.

It is obvious that this method of selectivity cannot be obtained by a simple receiving circuit in which the detector is inserted, because if the detector is reasonably delicate it is certain to be affected by all waves of approximately the same wave-length, whereas with an inductively coupled circuit only that wave having a frequency identical with the natural frequency of the receiving circuit will set the circuit oscillating with sufficient intensity to induce oscillations in the loosely coupled detector circuit.

The arrangement shown in Fig. 8 is adopted by the Telefunken Company, which employs crystal detectors of the kind shown in Fig. 9, which consist of a delicate metal contact that is pressed against a suitable crystal held in a clip or holder. The action of this type of detector is not yet thoroughly understood, but certain definite facts have been established. The oscillations induced in the circuit by the waves received are similar to the oscillations created in the transmitting circuit, and produce positive and negative currents oscillating alternately in opposite directions. Now it has been found in actual practice with crystal detectors that the current in one direction passes through the crystal between the contacts to a much greater extent than the current in the other direction, and the practical effect of this phenomenon is to separate from the oscillations a direct current which passes on and produces a sound in the telephone, or may be caused to affect some other device in the circuit by which the signals can be distinguished.

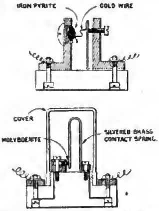

Fig. 9.—Sections of Telefunken detectors.

Crystal detectors are also largely used by the Marconi Company, carborundum being the crystal principally employed. The arrangement adopted is shown in Fig. 10, from which it will be seen that the crystal and telephone are arranged in series with a potentiometer, whereby a small current can be passed through the crystal.

With the object of still further increasing the sharpness of tuning and selectivity, the Marconi Company employ three circuits in their receiving apparatus, an intermediate circuit coupling the receiving circuit to the detector circuit. Each circuit contains a variable condenser and inductance, so that by finely tuning the circuits to the frequency of the waves to be received, and then by moving the coils in the intermediate circuit away from the coils in the receiving and detector circuits, a very loose coupling can be effected, so that only those waves having a frequency corresponding to the natural frequency of the three circuits will be able to excite oscillations in the detector circuit. The oscillations produced in a receiving circuit by a wave of different length to that wave-length for which the circuit is tuned are termed forced oscillations; and, although these forced oscillations may exist in the receiving circuit, and may possibly excite oscillations in the intermediate circuit, they are quickly damped down and give way to the natural oscillations produced by the waves corresponding in length to those for which the circuits are tuned. Hence with the Marconi multiple tuner there is very little possibility of those interfering waves reaching the detector circuit and "jamming" the signals intended to be received. It should be mentioned, however, that interfering waves can only be excluded in the manner described when the waves themselves are sharply tuned. A wave having a flat tuning would probably break through all the circuits and might cause serious interference in the detector circuit by drowning out the signals which are intended to be received. According to the law in most countries, however, sharpness of tuning in the waves transmitted from stations working on commercial wave-lengths is compulsory, and by means of this stipulation selectivity in wireless telegraphy is rendered possible. But in time of war laws are not considered, and it often proves of great value to radiate highly damped waves having a flat tuning so as to cause serious interference with the enemy's instruments and prevent the exchange of signals between their camps.

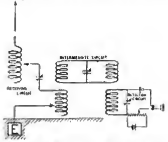

Fig. 10. Marconi crystal detector.

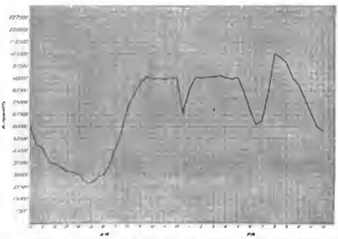

Fig. 1.—A typical load curve of a lighting central station for a normal summer day (1913).

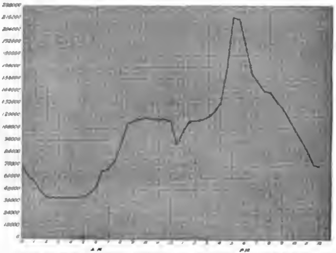

Fig. 2.—A typical load curve of a lighting central station for a normal winter day (1913).

The Storm Detector*

Its Influence Upon the Operation of Lighting Central Stations

By W. H. Lawrence

INTRODUCTION.

Such public utilities as those supplying gas and water are fortunate in that the commodities they distribute are physical materials. During those parts of the day when the demand for their product is small, the excess delivered from the station can be economically stored in a reservoir for use at later periods in the day when the demand is greater than the capacity of the station.

The public utility that distributes electricity, however, cannot be modeled profitably after this plan on account of the properties of the commodity that it handles.

Electricity, like light and sound, is not a physical material and therefore can exist only as long as the influence of its generating source continues. This property renders it impossible to directly store or preserve electricity for future use. Although such an end may be indirectly accomplished by the use of storage cells, which convert the kinetic energy carried by the current into potential chemical energy and later carry out the reconversion, the efficiency of this method is very low. For this reason, the use of storage batteries in supplementing the generation of electricity has been restricted to such purposes as involve the furnishing of a reserve to safeguard the service against interruption when some accident temporarily affects the generating, transmission or transforming systems.

Electrical stations, being unable to economically avail themselves of the use of a reservoir which may be charged with the excess energy of the station at light-load periods and discharged to assist the station at the heavy-load periods, have to be designed with a capacity equal to no less than the maximum demand upon them. This factor of an installed station capacity at least equal to the maximum peak load is the greatest financial handicap to which an electrical station is subjected. That this condition is unavoidable has long been recognized and accepted by our business men and engineers.

The variations in the load which are demanded of a lighting station during the day and the characteristic difference between the summer and winter loads are shown by Figs. 1 and 2, of which Fig. 1 is a typical load curve for a summer day and Fig. 2 one for a winter day. (A typical load curve for the month of March is shown in Fig. 3. It will be noted that the time at which the peak occurs lies between the hours of the winter and the summer peak.)

Since it is only during the peak load of the day that the whole equipment of the station is working, it is evident that the return on the entire investment during the remainder of the day must be earned by that portion of the equipment that is then operating.

This is a condition that makes it highly imperative that an electrical station be operated with maximum economy throughout the entire day. Given a certain station equipment, this is mainly accomplished by a strict adherence to a regular daily routine. Thus, at any period of the day only that number of machines is operated which is sufficient to economically carry the load then existing. At times of light load or average load, a steam-driven station will have a large share of its boilers "banked" and a number of its generating units idle. When under such a condition a large unexpected demand for an increased output may be made so suddenly that the number of machines which are operating will be insufficient to carry the abnormal demand, and it is probable that the standard of service will be lowered until such time as reserve boilers and generating units can be brought into service. For this reason it is imperative that the station receives preparatory warning of any abnormal demand.

The rapidly moving clouds which accompany a storm constitute the principal cause for the sudden and unexpected increases in the demand for current from a lighting station. The effect which a sudden and heavy storm may have upon the station's output is shown by the sharp peak at the 3:35 P. M. point of the curve in Fig. 4. This is the record of an actual occurrence which took place during the month of March, 1911. It will be noted from this curve, and by a comparison with that of Fig. 3, that the demand at 3:35 P. M. is 73 per cent greater than it would have been had there been no storm. An increase of 49,500 kilowatts, in this instance, was called for in about five minutes, which gives a good idea of the severe demands that may arise and which a lighting station must be prepared to meet.

Any device, therefore, that will provide a warning of the approach of a storm, at a time sufficiently far in advance to enable the station attendants to prepare for the exception to their daily routine in a deliberate and orderly manner, would be most welcome.

The storm detector is such a device.

STORMS AND THEIR EFFECT ON THE DETECTOR.

All summer storms, or practically all of them, are accompanied by electrical disturbances in the ether. These cover a field far greater than that over which the storm clouds themselves are visible. By use of antennæ, some of these radiations may be intercepted and by a suitable apparatus be made to give an indication of not only the presence but also the relative proximity of the storm.

The storms that occur during the winter months are usually snow storms and are of but a weak electrical nature. For this reason, they may perhaps not affect the device. At this season, that is a matter of but small moment. In winter the load upon the stations during the daylight hours is uniformly greater than during the summer, and the demand regardless of the severity of the storm will always be from 20 to 25 per cent less than the demand which occurs daily between 5 and 5:30 P. M., for which the station is always prepared.

This is evident when it is considered that winter storms have no effect on street lighting and other outside lighting, sign lighting, residence and apartment-house lighting, etc., all of which are on at the time of the daily peak at 5 P. M. For this reason, winter storms are of such minor importance that the service of the storm detector is dispensed with during that season.

DESCRIPTION OF STORM DETECTOR.

The various parts making up the detector are an aerial, a short-circuiting switch, a spark gap, a coherer, a relay and battery, a bell (which also acts as a decoherer) and battery, a condenser and a ground connection. Fig. 5 shows the diagram of connection of these parts.

Aerial.—Antennæ, similar to the more simple ones used in connection with wireless telegraph outfits, have been found to serve the purpose admirably. It is this part of the equipment that receives the ether radiations resulting from the storm.

The oscillating current thus set up travels to and from the ground through the spark gap, coherer and condenser.

Short-circuiting Switch.—This switch and its connections are shown in Fig. 5. Nominally, it is kept in the "open" position. After the alarm bell has begun to ring continuously, it is closed to protect the apparatus from heavy surges and to silence the bell.

Spark Gap.—This consists of a simple gap with spherical terminals placed approximately 1/64 inch apart. The purpose of this gap is to prevent those surges that are induced in the antennæ by the radiations emanating from wireless telegraph stations, but which are very weak as compared to the lighting disturbances, from flowing through the remainder of the apparatus and thus causing a false alarm.

Coherer.—This is also patterned after the type of the simple ones used in the early days of wireless telegraphy. In brief, it consists of a short section of glass tube of small bore loosely filled with nickel-silver filings. These are connected at each end to the outside circuit by German silver plugs. The action of such a type of coherer is well known, and needs no further explanation than to say that it acts as a high resistance to the low-voltage battery current impressed upon it until a high-frequency discharge current, between aerial and ground, has passed through it. This high-frequency current effectively lowers the coherer's resistance to the battery current, which consequently allows a greatly increased battery current to flow through the tube. The resistance of the tube then remains unchanged until it is violently jarred, at which time the high-resistance property returns.

Relay and Battery.—The most effective type of alarm is an audible one, of which the simplest form is a bell. However, as a bell requires a greater amount of current for its operation than that increased amount of battery current which is caused to flow in the coherer by a high-frequency discharge, some magnifying or relay device must be used. The relay employed is one of the ordinary telegraph type and the battery B_1, Fig. 5, is of dry cells. The connections are given in Fig. 5.

Bell and Battery.—The bell is one employing single-stroke connections and is of a size sufficient to be easily heard throughout the system operator's office. (The coherer, relay, condenser and bell are located in this office.) The bell has its own supply battery of dry cells, B_2, and is controlled by the secondary contacts of the relay, as shown in Fig. 5.

As the low-resistance condition into which the coherer is thrown by a high-frequency discharge is permanent until the tube is severely jarred, the bell is mounted so that its clapper will strike the tube and thus perform the two-fold function of bell and decoherer. (It is evident that the tube must be decohered, otherwise it would not show the effect of a later high-frequency discharge.)

Condenser.—The condenser is an ordinary one and is inserted in the ground wire to prevent stray direct current from flowing in the apparatus.

Ground Connection.—This connection completes the high-frequency circuit from aerial to ground.

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* Reproduced from the *General Electric Review*.

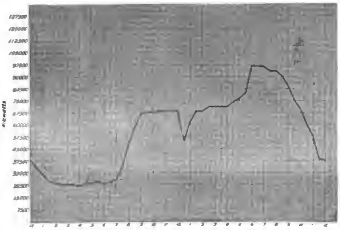


Fig. 3.—A typical load curve of a lighting central station for a normal March day (1911), when the conditions of operation were normal, and the load curve follows a regular daily cycle.

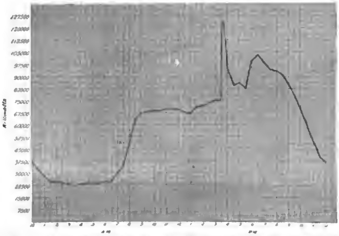


Fig. 4.—An example of a load curve of a lighting central station for a March day (1911), during which a severe unexpected storm took place at 3:30 P. M. But for the abnormal peak occurring because of this storm, the curve would be similar to that of Fig. 3.

OPERATION.

The operation of the apparatus comprising the storm detector leaves practically nothing to be desired. The manner in which it enters into the activities of a steam station will be described, as it is perhaps to such a station that it is of the most benefit.

It will be remembered that the bell or decoherer, together with the coherer and relay, are located in the system operator's office.

It is the duty of the system operator that he keep continuously posted on the demands that are or may be made upon the station for power and to so direct the disposal of all the generating machinery that the station will afford the highest quality of service and will operate with the maximum degree of economy. In detail, the latter function he performs by orders to the boiler room specifying how many boilers shall be maintained under load and how many shall be carried "banked," by instructions to the generating room as to which machines shall carry the load and which other units and auxiliaries shall be held idle or in readiness, and by orders to the various switchboard operators as to which feeders shall be used in the disposition of the output

Under the usual daily conditions of operation the demand which will be made upon the station from hour to hour is accurately known, for the variations of the load curve constitute a daily cycle. These regular changes of load, being anticipated and taken care of by orders from the system operator, become a matter of station routine.

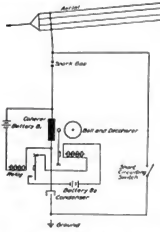


Fig. 5.—Complete diagram of connections of the apparatus comprising "the storm detector."

In order to secure smoothness of plant operation, the system operator is informed of the unusual departures from the regular load curve that are to be expected, e. g., exhibition lighting, etc., and also of the weather forecasts. All such is of great assistance in aiding good management. Those unusual irregularities of whose coming he is reliably warned present no difficulties. It has been found by operating experience, however, that the weather forecasts come far from providing a reliable and early warning. Further, the reports are not couched in such terms as furnish the system operator with the information that is of paramount importance to him, viz., the rapidity, in hours, of the approach of the storm.

It is true that the number of severe storms which come over a city with extreme rapidity is much less than that of the slower moving storms, but, on account of their tremendous capacity for suddenly deranging the orderly routine of the lighting station and perhaps even affecting the standard of its service, the fast moving storms make it requisite that all are to be guarded against.

Assume, for instance, such a storm to be approaching a city in which is located a lighting station that possesses a storm detector.

At a time varying from two hours to seven hours before the actual storm clouds reach the city (depending upon whether the path of the storm is a direct or a roundabout one), the alarm bell will begin to strike at intervals of from five to fifteen minutes. The system operator regards this merely as the warning of the possible approach of a storm but gives it no further attention, for the storm may change its direction and pass off without molesting the quiet weather conditions of the city.

The disturbing conditions by their further approach cause the bell to ring oftener. With the storm but about two hours' travel away, the bell will strike about once every half minute or every minute. When this occurs the system operator orders the reserve boilers into service, the auxiliaries of such generating units as he deems may be required started, and the generating units themselves run at low speed.

These conditions prevail until that later time when the bell gives an insistent warning by uniting its periodic strokes into a continuous ringing. This will ordinarily occur at about one half hour to one hour before the storm reaches the city. It has been found quite often that even at this time the sky will remain clear and unclouded to the eye, which shows how much superior are the services of a storm detector to those of a watchman stationed upon the roof to observe the conditions prevailing in the sky. (This latter practice was the best one available prior to the development of the storm detector.) The switch short-circuiting the detector is closed when the bell begins to ring continuously to protect the receiving apparatus, for the storm will now be comparatively close, and to silence the bell, for its warnings are no longer needed, since it is positively known by this time that the coming of the storm is a certainty. Simultaneous with this action goes the order to synchronize the incoming generating units with the bus. Everything is now in readiness to supply the increased load which will be demanded in but a matter of minutes.

The following are actual records of the frequency of the bell warnings and the loads existing at various times preceding two storms last year.

July 28.
1:45 P. M.............. 1 bell.
2:15–3:30 P. M....... 1 bell every ½ to 1 minute.
3:30 P. M............ bell began ringing continuously, load 98,000 kilowatts.
4:15 P. M.............(very dark, heavy rain storm), load 142,500 kilowatts.
August 1.
8:25 A. M.–2:00 P. M... 1 bell every 3 to 5 minutes.
2:02 P. M.–2:15 P. M... 1 bell every ½ minute, load at 2:00 P. M., 100,000 kilowatts (cloudy).
2:15 P. M.–3:20 P. M... bell ringing continuously.
3:45 P. M.............load 150,000 kilowatts.

APPLICATION OF THE DETECTOR.

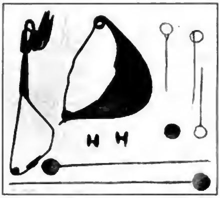
The storm detector as described is in service and located in the office of the system operator in the waterside stations of the New York Edison Company. These stations, so far as it is known, are the only ones possessing a device of the same nature.

The field for such a device among steam-driven lighting stations would seem to be in the larger cities, particularly in those which possess crowded office districts, as it is the load derived from such a source that is most sensitive to changes in daylight.

A field in which it would also seem that the device would furnish valuable service is that of keeping the isolated hydro-electric station informed as to the weather conditions existing in the distant cities which it is supplying with lighting current. The places of generation and consumption being so far separated, a visual observance of the weather conditions at the power plant would be of no use. By means of storm detectors located in a few of the widely separated towns which receive lighting current from the station, the attendants may keep forewarned by a bell in their station as to the irregular demands which may be made on them by storm clouds passing over those distant towns.

The Antiquity of Some Common Articles of Apparel

There is nothing new under the sun: not even a collar stud. It may be rather surprising to the reader that the Romans possessed collar studs, for whoever saw a Roman wearing a collar? The fact is, he did not use the stud to fasten his collar, but perhaps to hold together other garments, and, incidentally, he also applied it to an entirely different purpose, namely, as a caster for chair legs, etc., somewhat after the manner of an article known on the market to-day as "domes of silence." Other articles which have been found among Roman relics are various forms of safety pins, and some hair pins fashioned like the hat pins of to-day. There were also clasps in use which seem to have served to fasten a bouquet to the Roman ladies' dresses.



Safety pins, clasps, "collar studs" and hair pins of Roman antiquity.

For Shunting Purposes at the Cleveland ore docks, with a view to avoiding the inclusion of the shunting engine among the cars being shunted, the Pennsylvania Railway has introduced locomotives which have the peculiarity that they do not run on the same lines as the cars they handle, but on a narrow gage parallel line. Each engine has an arm on each side which can be lowered by means of compressed air controlled from the cab, and acts as a pusher. The locomotives are of Baldwin-Westinghouse make, and are 25 tons in weight. Power is obtained from two rails lying inside the rails on which the locomotives operate; these rails are protected by a wood covering.

The Preservation of Wood—II*

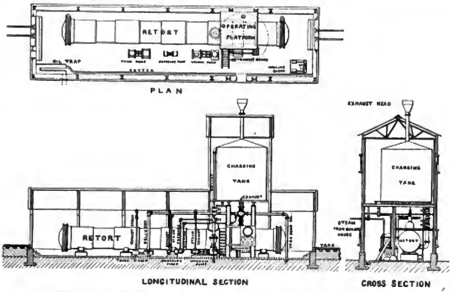
A Synopsis of the Principal Processes in Use To-day

By A. J. Wallis-Tayler

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2012, Page 54, July 25, 1914

The Dead Oil of Tar Process or "Creosoting."—John Bethel evolved in 1838 a practical process for the injection of hot creosote oil, or dead oil of tar, into wood to be preserved, the operation being performed in a closed vessel or retort under pressure. This process is now universally known as "creosoting," which, however, is a misnomer, as dead oil of tar or creosote oil actually contains no real creosote.

The substance owes its success as an antiseptic agent to the presence of insoluble non-volatile substances indifferent to the attacks of oxidation or putrefaction under the conditions to which its product is normally exposed. Naphthalin ($C_{10}H_8$), which is a hydrocarbon occurring in large quantities in the heavy coal oil (naphthalin compounds amount to from 30 to 60 per cent by weight), is in its pure state a white substance, taking the form of closely adhering rhomboidal crystals fusing at 79 deg. Cent. (174.2 deg. Fahr.), vaporizing at 212 deg. to 220 deg. Cent. (413.6 deg. to 428 deg. Fahr), and having a specific gravity of 0.9778 at its boiling-point; insoluble in cold water, slightly soluble in hot water, and slightly volatile at normal temperatures.



LONGITUDINAL SECTION CROSS SECTION

Fig. 8.—Pressure creosoting plant with one cylinder or retort and accessories.

The heavy or dead oil of tar used for creosoting, according to Mr. Rowe, should not contain more than 1½ per cent of water, 5 per cent of tar, and 5 per cent of phenol or carbolic acid. It must not flash below 85 deg. Cent. (185 deg. Fahr.), nor burn below 93.3 deg. Cent. (200 deg. Fahr.), and must be fluid at 48 deg. Cent. (118 deg. Fahr.). It should begin to distil at 160 deg. Cent. (320 deg. Fahr.), and should yield between that temperature and 210 deg. Cent. (410 deg. Fahr.) of all substances less than 20 per cent by volume. Between 210 deg. Cent. (410 deg. Fahr.) and 243.3 deg. Cent. (470 deg. Fahr.) the yield of naphthalin must not be less than 40 per cent, nor more than 60 per cent by volume. At 2 degrees above its liquefying point it should have a maximum specific gravity of 1.05, and a minimum specific gravity of 1.015.

The "creosoting" process undoubtedly gives excellent results, and is extensively used in this country and in America. Although the first commercially practical plant appears to be due to Bethel, an authentic record of the use of creosote oil, for impregnating timber, as far back as 1756 is said to exist. Bethel's experiments showed that by impregnating the wood with a minimum of 7 pounds of creosote per cubic foot, satisfactory results were obtained in the case of railway sleepers; for marine work he considered that not less than 10 pounds per cubic foot was required. Other experimenters have employed from 10 pounds to 20 pounds per cubic foot. This question will, however, be gone into later.

A standard method of carrying out the creosoting process is as follows: The wood for treatment, having been carefully dried, is steamed and subjected in a retort to the action of a heated vacuum of from 22 to 24 inches, so that the thorough and uniform penetration of the preserving liquid or agent, essential to the highest efficiency, may be insured.

The creosote oil or dead oil of tar is then admitted to the chamber, which latter is still maintained connected with the vacuum pump, at a temperature slightly above that of the boiling point of the sap at the pressure in the retort at the time. During the time that the hot oil is surrounding the wood, and penetrating into the interfibrous spaces, any aqueous vapor that still remains in the wood rises to the top of the chamber, owing to its lesser specific gravity, and is drawn off by the pump, and when the chamber is completely filled with oil all the remaining moisture has passed off.

The exhaust pump is then cut off, and, to facilitate and expedite the impregnation of the wood, a force-pump is started by means of which creosote oil is forced into the chamber or retort until the desired pressure, generally about 150 pounds per square inch, is attained. This pressure is held until the wood has received the required amount of the antiseptic agent. The oil remaining is then withdrawn from the retort and dumped into an underground tank, from where it is pumped back into the measuring tank, the difference in the reading of the tank gage before the oil is put into the retort, and after it is pumped back into the tank, giving approximately the amount of creosote oil injected into the wood.

The impregnation being complete the retort is opened, the treated wood removed, and another charge can be inserted. The above practice, it will be seen, consists of two distinct operations, the preparation of the wood and the impregnation of the prepared wood with the preservative agent.

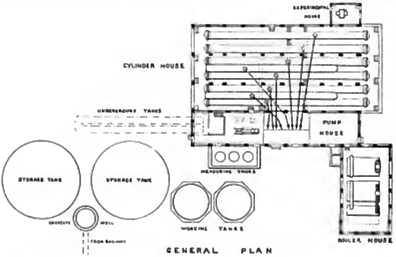
The preparation of the wood consists essentially in the extraction of the liquids, and semi-liquids, which constitute the immature portion of the wood, and are contained in the interstices between the fibers, without softening the cement binding of fibrillæ or bundles of cellulose tissue which form the solid or fully matured portions of the wood. The above operation removes all those portions of the tissue which are liable to fermentative action, and the value of artificially preserved wood depends entirely upon its successful accomplishment.

The amount of pressure to which the wood is subjected in the retort during impregnation is a matter of considerable importance. A high pressure tends to expedite the operation, but it must not be overlooked that too high a pressure is liable to cause injury to the fiber of the wood, by forcing in more of the agent than the natural voids can hold.

The general opinion among experts seems to be that pressures of from 100 pounds to 180 pounds per square inch are the most advantageous, the higher pressures being required for creosote oil and the lower for other agents. Besides injury to the wood, over-pressure also causes a considerable waste of the agent, as when an amount of the latter in excess of the absorptive power of the wood has been injected, the surplus will waste out after the wood has left the retort and be lost. A considerable pressure in the retort, even as high as 300 pounds per square inch, may not at first affect the strength of the fibers of the wood to any appreciable extent, but it may be the cause of serious consequences in after years.

Should the treatment be carried out at too low a temperature, or for too short a period, only the sap or liquid part nearest the surface will be removed, and the space receiving the preservative agent will not be sufficient. Conducting the operation at too high a temperature, or for too long a period, on the other hand, will result in the resinous portion of the bundles of fibrillæ becoming softened and the elasticity of the wood being reduced in a proportion corresponding to the decrease in the coherence of the fibrillæ. According to the practice of the Norfolk Creosoting Company, U. S. A., the temperature should never be less than 100 deg. Cent. (212 deg. Fahr.), or exceed 130 deg. Cent. (266 deg. Fahr.).

Of the two possible methods for the removal of the undesirable portions of the timber, exposure to currents of dry air, and steaming under pressure, with an after-drying in a vacuum, the latter is recommended as the best practice. Although the first method would seem to be the least likely to modify injuriously the physical structure of the wood; in actual working this is found not to be the case. With proper manipulation, a more thorough desiccation, without harmful change of the



GENERAL PLAN

Fig. 9.—Pressure creosoting plant with multiplicity of cylinders or retorts.

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*Paper read before the Royal Society of Arts, and published in its *Journal*.

organic structure, can be accomplished in twelve hours less by the latter process than is ever possible with air drying, which, under the most favorable circumstances, is a long drawn-out operation, and, in any case, cannot do more than extract the water from that portion of the sap which has not yet reached the semi-solid stage; thus leaving in the tissues of the wood a very considerable amount of resinous matter, which occupies space that should be ready to receive the preservativa agent. The consequence of this is a failure of the oil to reach many of the interfibrous passages, which are either left empty, or are filled with the gelatinous part of the half-matured growth cells in which are to be found the conditions that make putrefaction possible. In order to remove the sap from wood, it is first necessary to vaporize it and then to bring about such external circumstances as to allow of the outflow of all gaseous matter from the interior of the wood. To vaporize the sap it is necessary to break down the walls of the cells containing the liquid and the semi-liquid substances. This can be readily accomplished through the agency of heat applied through the medium of a moist steam bath at such a pressure as to keep tha temperature of tha wood, and its surrounding atmosphere, somewhat abova the boiling-point of the sap. The maintenance of this condition for a few hours is said to be found to be quite sufficient to break down the sap-cell tissue, and to vaporize all those constituents that it is desirable to withdraw. This point having been reached the steam bath is discontinued, and the temperature being maintained at, or slightly above, tha vaporizing point of the sap, the pressure of the atmosphere surrounding the wood within the retort is reduced below that of the interior of the wood. The result of this condition would be an overflow of vapor and air, continuing until equilibrium was restored. This equilibrium is prevented by the use of an exhaust pump until the absence of aqueous vapor in the discharge from the pump indicates the completion of the operation. At this stage the tissue is in a stata very like that of a sponge cleared of hot water, every pore is gaping open and ready to receive tha agent.

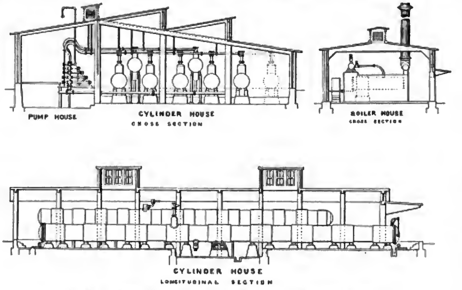


Fig. 10.—Pressure creosoting plant with multiplicity af cylinders or retorts.

To insure success requires most careful attention and skillful management, and, of course, the provision of adequate and suitable appliances. The attainment of a more or less perfect product demands the consideration of the following points: the wide divergence in the characteristics of timber; the varying amounts of sap due to the lapse of time since, and the season in which the tree was felled; its possible subsequent immersion in water for a longer or shorter time; the character of the soil and the conditions under which the tree grew, whether in a dense forest or a comparatively open country; whether it is of a rapid even growth, or of a slow, intermittent one. To an experienced operator these conditions indicate in each case tha proper course to be pursued, and failure to observe and to take them into consideration is to invita indifferent, uncertain, and, in the end, unsatisfactory results.

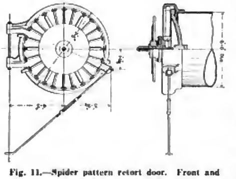


Fig. 11.—Spider pattern retort door. Front and side elevations.

Of almost equal importance is a proper understanding of the circumstances under which the finished product is to be used. Timber of piers, wharves, and other structures in tropical waters, demands processes and degrees of thoroughness of treatment that are unnecessary in the harbors of more temperate climates, which latter are in turn more exacting than land and fresh water constructions.

The time required to treat any particular wood depends upon the structure, size of wood, shape, and the method of treatment of the wood. For operating the full creosote process with 10-pound treatment, the cycle is as follows: Steaming to 20 pounds pressure, 30 minutes; steaming to 20 pounds to 35 pounds pressure, 3 hours 30 minutes; blowing off, 15 minutes; vacuum, 45 minutes; creosote oil to a pressure of 100 pounds per square inch, 1 hour 30 minutes; forcing back solution, 15 minutes; vacuum, 15 minutes; total, 7 hours.

A simple installation, with one creosoting cylinder or retort and necessary accessories, constructed by tha Power and Mining Machinery Company of Cudahy, Wis., is shown in plan, and in longitudinal and transverse sections in Fig. 8. This plant comprises one steel creosoting cylinder or retort; a steel charging tank placed at a level above the retort, and also storage measuring and underground tanks, not shown in the drawing; tie block and bolster cars for handling the timber in and out of the retort; vacuum pumps and condensers for withdrawing the moisture, sap, and surplus preservative; general service or tank pumps for transferring the preservative fluid from the tanks to the retort; pressure pump for injecting the preservative into tha wood cells; centrifugal pumps for transferring the preservative, and for agitating the hot creosota oil; air compressor for blowing back tha oil from tha retort to the tanks, and for agitating and impregnating purposes; pumps for fire protection; feed pumps for boilers; feed-water heaters, open and closed patterns, for preheating boiler-feed work. Also necessary boilers, buildings, hoisting engines, locomotives, generators, motors, requisite piping, valves, special fittings, thermometers, direct and recording pressure and vacuum gages, multiplying float indicators, etc.

Obviously, by multiplying the number of impregnating cylinders or retorts and accessories, the plant may be increased to any desired capacity.

Fig. 9 is a general plan, and Fig. 10 shows longitudinal and cross sections of a plant having a multiplicity of impregnating cylinders or retorts constructed and erected by the Allis-Chalmers Company at Somerville, Texas.

The commercial sizes of the retorts made by the above company are as follows: 72 inches diameter, and 74 inches diameter by 42 feet, 52 feet, 108 feet, and 132 feet in length; 84 inches diameter by 108 feet, and 132 feet in length; and 108 inches diameter, by 132 feet, and 150 feet in length. The shells of the retorts are made of tha very best open hearth flange steel of thicknesses ranging from ⅝ inch to 1 inch, depending upon the diameter, working pressure, and preservative agent used, some of the latter causing rapid deterioration of the platea, while others have no injurious effect. The retorts are fitted with the usual rails and steam-heating coils for creosote.

The door of the retort is a most important detail. For low pressures the patterns recommended are, either a plain bolted one with slotted holes and ordinary tee-head bolts; or what is known as a "spider" door with center screw and lever nut arranged so that each lever has independent connection with the frame, such as that shown in front and side elevation in Fig. 11. For high pressures an improved "spider" door, with center screw and lever nut, arranged so that the levers are connected to the frame by a continuous flange ring, would be found suitable; or a solid cast steel bolted door with tee-head swing bolts, such as that shown in front and side elevation in Fig. 12, can be used. All the patterns of doors should have a projecting circular spigot on the door which corresponds with a circular groove in the frame, so that a sound joint can be formed by tha insertion of a gasket in the groove. This gasket is usually made of asbestos rope thoroughly dipped and painted with a mixture of graphite and oil. The retort is sometimes fitted with a door at each end.

The opinion of operators as to the best type of door varies, but it may be said that, in cases where time is an important factor, the "spider" door is probably the best, as it can be opened and closed in about 2½ minutes, whereas the bolted doors occupy at least double that time. The bolted doors, however, have less parts, therefore they require less maintenance than the "spider" doors.

The practice in the United States, in the case of what is usually termed the "full-cell creosote process," is to employ a pressure of from 100 pounds to 125 pounds per square inch, the wood fibers and cells of ties or sleepers being impregnated with from 6 pounds to 12 pounds of creosote oil per cubic foot, and piling with from 10 pounds to 20 pounds per cubic foot. Sometimes the wood is subjected to a vacuum at the finish to drain the surplus oil from the exterior of the wood, and thus to prevent loss by drippage after the wood has been removed from the retort. The time occupied in this treatment, omitting steaming, is 3 hours, including steaming; 5 to 7 hours, for sleepers; for timber, including steaming, the time occupied by the treatment is 7 to 11 hours; and for piling, 12 to 24 hours.

The open-tank hot or boiling creosoting process allows of two steeps a week being made. The creosota oil should be heated up to 93 deg. Cent. (199.4 deg. Fahr.) for 8 to 10 hours, to whola of tha working day, and allowed to cool during the night. This operation is repeated next day, and when tha creosote oil is quite cool the timber can be extracted.

The open-tank cold process occupies from 9 to 18 days, the time taken in absorbing the agent depending greatly upon the species of timber being treated. In both of the abova processes especial care is necessary to see that the timber is thoroughly dry before treatment.

Regarding the efficiency of the open-tank method of preserving wood, Mr. Rowe observes that sleepers, and any wood that will make a good paving-block, must be well dried before it can be properly impregnated by this method, and this seems to be the secret of success. Mr. Card, manager of the Chicago Tie and Timber Preserving Company, states that the open-tank method of creosoting will undoubtedly produce good results if it is confined to the treatment of blocks, shingles, posts, etc., or, in other words, small dimension lumber, and it will not be successful in this case unless the utmost care is taken in the seasoning of the lumber before treatment. As regards the treatment of sleepers by this method, he says that a loblolly pine sleeper, provided it is thoroughly seasoned, would probably absorb the greatest amount of solution in the least time, but any other class of sleeper treated on the open-tank method

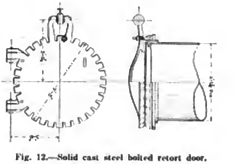


Fig. 12.—Solid cast steel bolted retort door. Front and side elevations.

would take from two to three weeks to absorb the same amount of solution that could be injected under 100 pounds pressure per square inch in 4 hours' time.

The Curtis-Isaacs Creosoting Process.—A process for creosoting, patented some years ago in the United States by W. G. Curtis and J. Isaacs, of San Francisco, consists in placing the charge of timber to be treated in a retort having open vents or ports to the atmosphere, introducing sufficient oil of creosote to submerge the charge, and then heating the oil and timber to a temperature above the boiling-point of the sap at ordinary atmospheric pressure, by which it is claimed that the sap is expelled from the wood. The ports or vents are then closed, and the oil is forced under pressure into the pores of the wood to take the place of the evaporated sap.

The Rueping Process.—Briefly, this process, which is chiefly used with oil of creosote as an agent, consists in forcing compressed air at a pressure of from 80 pounds to 100 pounds per square inch into the pores or cells of the wood (previously either air-seasoned or steamed in a retort), and, at a higher pressure, creosote oil, without relieving the air pressure.

The retort is filled with oil by means of an equalizing reservoir or pump, so as to avoid releasing the air pressure. The oil pressure thus started at from 80 pounds to 100 pounds per square inch is then gradually increased to about 150 pounds per square inch, compressing the air that has been forced into the cells or pores of the wood into a smaller volume, and allowing from about 10 pounds to 12 pounds of creosote oil per cubic foot to enter the wood.

Upon relieving the combined air and oil pressure, and draining the oil from the retort, a vacuum, or rather a partial vacuum, is produced therein, which permits the air inclosed in the cells or pores of the wood to expand and force out the surplus oil from the wood fibers, leaving the latter impregnated, according to some authorities, with from 4 pounds to 6 pounds of creosote per cubic foot, and, according to others, with as little as 2.2 pounds per cubic foot.

This process is claimed to be especially adapted for the treatment of ties or sleepers. The time occupied in treating sleepers, omitting steaming, is about 4½ hours, or, including steaming, 6½ to 8½ hours. The time occupied in carrying ou' the different stages of the process, using equalizing [illegible] follows: Air to 80 pounds pressure per [illegible] minutes; transferring creosote oil, 20 [illegible], creosote oil to 150 pounds pressure per square inch, 1 hour 30 minutes; maintaining 150 pounds pressure per square inch, 15 minutes; forcing back creosote oil, 20 minutes; vacuum, 1 hour; maintaining vacuum, 15 minutes; draining, 10 minutes; total time occupied, 4 hours 20 minutes.

The Rueping process has been patented in Great Britain, Germany, and the United States. It was primarily devised with the object of reducing the cost of creosoting by preventing the heavy loss occasioned by dripping in the wood treated by the ordinary process.

Messrs. Richard Wade, Sons & Co., of Hull, are concessioners for the Rueping process in the United Kingdom, and several large firms have taken up licenses for the working of the plant. In this country, the writer understands, the usual practice is to force the compressed air into the wood at a pressure of about 50 pounds per square inch.

The Lowry Process.—In the Lowry process the seasoned wood is placed in the retort and submerged in creosote oil, from 10 pounds to 12 pounds of which, per cubic foot of wood, is forced in at a pressure of about 180 pounds per square inch, so as to saturate the pores and cells. The retort is then drained, and a quick vacuum produced and maintained from 1 to 2 hours, leaving the wood fibers finally impregnated with from 4 pounds to 6 pounds of oil per cubic foot.

This process is chiefly intended for the treatment of sleepers, and the time occupied in the impregnation of thoroughly air-seasoned wood is from 4 to 6 hours. The details of the process are: Creosote oil, 2 hours; draining creosote oil from retort, 10 minutes; vacuum, 2 hours; draining, 10 minutes; total, 4 hours 20 minutes. The average temperature of light creosote oil during the treatment is 77 deg. Cent. (170 deg. Fahr.), and of heavy creosote oil 82 deg. Cent. (180 deg. Fahr.).

The Zinc-creosote or Rutger Process.—According to this process, which appears to have been first introduced in Germany by Julius Rutger in the year 1874, the wood, first air-seasoned, or steamed in a retort—preferably both—to reduce moisture and expel the sap, is subjected to a vacuum for 1 hour. The retort is then filled with a hot emulsion formed of ½ pound of dry zinc, from 1.5 to 4 pounds of oil of creosote per cubic foot of timber being treated. Pressure is next applied by forcing in additional emulsion at a pressure of between 100 pounds and 150 pounds per square inch, after which the retort is drained and a vacuum produced and maintained for about ½ hour, to draw out the surplus emulsion from the exterior of the wood, and so prevent loss—as in the process previously described—by dripping after the wood is removed from the retort.

It should be noted that it is necessary either to employ a special oil, or to keep the emulsion in a constant state of agitation during the operation, in order to prevent a separation of the zinc and the creosote oil. The requisite agitation is usually effected by a centrifugal pump, which draws the emulsion from the top of the retort, and discharges it into the bottom through a perforated pipe.

This process, which is likewise intended principally for the treatment of sleepers, requires for the latter, including steaming, from 6 to 9 hours. The full details of the treatment are: Steaming to 20 pounds pressure per square inch, 30 minutes; steaming to 20 pounds to 35 pounds pressure per square inch, 3 hours 30 minutes; blowing off steam, 10 minutes; vacuum, 1 hour; emulsion to 120 pounds pressure per square inch, 1 hour; maintaining 120 pounds pressure per square inch, 1 hour 30 minutes; forcing back oil, 15 minutes; vacuum, 20 minutes; draining, 10 minutes; total, 8 hours 25 minutes. The steaming time is frequently reduced by 2 hours, in which case the time occupied would be 6 hours 25 minutes.

The above process is sometimes, especially in the United States, known as the Card process, from Mr. J. B. Card, who has introduced several improvements in working.

The Hasselmann Process.—The wood, seasoned or steamed or both, is placed in a retort which is then closed, and a vacuum pumped for about 1 hour, the solution being then admitted with the vacuum still on. The solution consists of 1.5 per cent of copper sulphate $(CuSO_4 + 5H_2O)$, 0.5 per cent solution of aluminium sulphate $(Al_2 3SO_4)$, and potassium sulphate (K_2SO_4) in proportion in accordance with the condition of the timber. When the retort is about filled, the main valve is shut and live steam is turned into the solution, through which it is distributed by a perforated pipe, heating the solution to from 118 deg. Cent. to 120.6 deg. Cent. (245 deg. Fahr. to 260 deg. Fahr.), and giving a gage pressure of about 35 pounds per square inch. The wood is kept in this boiling solution for from 2 to 3 hours, when the latter is drained off into a storage tank, or is transferred to another retort.

The main factor in the success of this process is the proper proportioning of the various ingredients in the solution to suit the kind of wood to be treated.

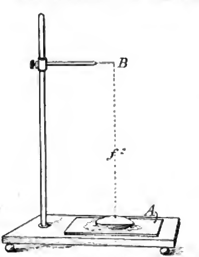
The plant used for the burnettizing process can be used for this process, extra tanks for holding the solution and tanks for mixing the chemicals being, however, required, as well as some slight minor alterations in piping, etc.

(*To be continued*)

Determination of Refractive Index of a Liquid

The following simple method of finding the refractive index of a liquid available in small quantities may be of interest. It is given by G. N. Pingriff in *Nature*.

A plane mirror, *A*, is placed on the base of the stand, and on it is put the double convex lens in such a position that its center is beneath the needle-point *B*. With the eye directly above *B*, the observer adjusts the sliding arm until the needle-point and its image just coincide, as found by parallax. The distance from *B* to the center of the lens is then accurately found—let it be f_0. The experiment is then repeated, after first placing a drop of the liquid upon the mirror, when it will be spread out to a plano-convex lens between the glass ' ns and the mirror—let the new focal distance be f_1; then evidently the focal length f of the liquid lens will be given by $1/f = 1/f_1 - 1/f_0$.



Simple method of determining the refractive index of a liquid.

But since the focal length of the liquid lens is also given by the relation $1/f = (\mu - 1)/r$, where r is the radius of curvature of the surface of the glass lens, it is evident that from a knowledge of r the index of refraction of the liquid can be at once found.

If r is not known, it can be found by putting a sheet of paper between the lens and mirror, and again obtaining an image of *B* coincident with itself by reflection in the lower surface of the lens. If this new distance from the lens be called d, we have, since refraction is now only at the upper surface of the lens, $\mu/r - 1/d = (\mu - 1)/-r$, or $r = (2\mu - 1)\ d$, where μ now, of course, refers to the glass, and can, if necessary, be calculated.

The apparatus is thus complete in itself, and three readings of the positions of *B* give all the data required.

Redwood Sawdust is being used by vineyardists in California for packing fresh table grapes. It takes the place of the ground cork used for imported Spanish grapes.

There are About Thirty-seven Pines native to the United States, of which twenty-five are Western species and twelve Eastern.

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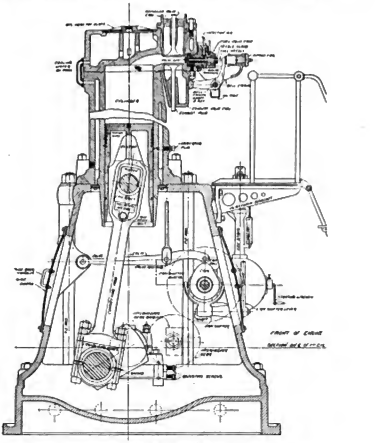
PHOTOGRAPH OF A FIGHT WITH A SHARK TAKEN UNDER WATER WITH THE WILLIAMSON APPARATUS.

The Diesel Engine*

Its Principles of Operation, Applications and Possibilities

The development of the internal combustion engine has made tremendous strides in the last few years. This is especially true of one type in particular, the Diesel engine.

The unparalleled progress of this prime mover, due primarily to the expiration of the basic Diesel patents, has created a wave of enthusiasm the crest of which swept over this country only a short time ago. To the careful observer, however, signs of an ebbing of this wave are apparent, and more sober, more healthy views are rapidly gaining ground. The application of the engine to marine work, especially to vessels of certain classes, has been especially noticeable, and the marine interests of the country have been watching closely the work of the Diesel engineers. Other applications of the engina are common, and the Diesel engine of to-day is apt to be found in almost any line of work.



Sectional view of a Diesel oil engine.

In spite of the fact that the name Diesel has spread over the world, but few engineers in fields other than combustion engineering have ever taken the time to thoroughly study the movement of the engine and to learn of its proved practical application and use to the engineering world.

The purpose of this article is, therefore, to present to the general engineer and the growing student an idea of what the Diesel engine is, and to show in what fields the greater possibilities of the engine lie.

This type of engine may be defined in a few words as follows:

An internal combustion engine which takes its fuel—crude, lowest grade of fuel oil, or the residues from oil refining—into the cylinders, raw, without any previous transforming, and there converts it into energy, exerting that energy directly on the crankshaft through pressure on the piston head, without any intermediaries, producing the simplest, most direct and economical operation.

PRINCIPLE OF OPERATION.

The cycle of operation of the Diesel engine operating on the "four-stroke-cycle" comprising the Diesel ignition-compression is as follows:

Stroke 1. Admission. Piston travels down or out, allowing cylinder to fill with pure, fresh air from the inlet valves.

Stroke 2. Compression. Piston travels up or in, compressing air in cylinder. Compression heats the air so hot that the oil discharged into it will ignite and burn.

Stroke 3. Working down or out. At the beginning of this stroke, when the crank is on dead center, the fuel valve opens and the fuel charge of oil is sprayed into the heated air of the cylinder by a jet of air separately compressed by a small compressor. The spraying extends over 12 per cent of the working stroke of the piston, and the combustion is gradual, the resulting pressures being even and sustained, and not explosive.

Stroke 4. Exhausting. When the piston reaches the lower or outer end of the cylinder on stroke 3, the exhaust valve is opened, the pressure relieved and the piston travels up or in, driving out the exhaust gases of combustion.

LARGE DIESEL ENGINES.

Owing to the steady application of its power, the lack of vibration, comparative noiselessness, reliability and to the small space which it occupies, the Diesel engine has become an almost ideal engine for marine work where oil may be had at nominal prices. An idea of the ease with which a Diesel engine may be controlled, may be had from experiments run with the British motive ship "Eavestone." This vessel is a ship of 4,310 tons displacement recently built by Sir Raylton Dixon Company, Ltd. The 800 horse-power Diesel engine was largely built and installed by Richardsons, Westgarth & Co., Ltd., of Harthpool under the supervision of Messrs. Carel's. She was capable of doing something over 9 knots. The handling of the engines was very smart; they were reversed from full ahead to actually running astern in from 9 to 10 seconds, and this without any haste; in fact, with intentional deliberation. It was stated that the reversal had actually been completed in the remarkable time of 6 seconds. Observations showed that it only took about 3 seconds from the ringing of the telegraph till the engine was actually running ahead, the gear being already in the ahead position. Units of this character have been built for marine service up to about 2,000 horse-power single-acting type. The double-acting types are as yet but in the experimental stage.

ESTABLISHED POPULARITY OF THE SMALL DIESEL ENGINE.

The small and medium Diesel engine in sizes of 40 or 50 horse-power in single-cylinder units, up to about 600 horse-power in four-cylinder units, plays a vastly more important part in the commercial world; it has unquestionably come to stay, and has reached a high degree of perfection which places it right in line with the corresponding steam or gas engine plant as far as reliability and cost of operation are concerned, and far ahead of its competitors when considered from the standpoint of fuel economy. It is amazing to note how many manufacturers of gas and steam engines have taken up the manufacture of Diesel engines, because they found that the sale of suction-gas producer plants and smaller steam engines has fallen off alarmingly within the last few years.

The reason is plain: The single-acting four-cycle, single or multi-cylinder Diesel engine, but particularly the former, is comparatively simple in construction and operation. It does not require up-keep and attendance of boilers or gas producers, and its cost compared with that of steam or gas plant is reasonable. It can be installed in the basements of buildings below occupied dwellings. One of the greatest advantages, however, is the fact that the actual fuel consumption of Diesel engines taken over long periods of operation does not materially exceed the guaranteed figures, whereas in gas-producer and steam plants this excess is quite considerable. In a Diesel plant the human element—the skill of the operator—has much less influence upon the fuel economy than in a steam or producer-gas plant, where everything depends upon the efficiency and intelligence of fireman and producer attendant.

On account of its low cost and great simplicity and variety of fuels which can be utilized, the engines are being used and installed for various purposes; for instance: For power transmissions, for operating flour mills, for lighting factories, sanatoria, office buildings, department stores, for electrical works, etc.

Lately, they have been applied to the production of power where new and additional equipment is found necessary. It has been found that this engine can be very economically maintained as a reserve for relieving the original units of the peaks of the load and for like purposes.

The efficiency of this type of engine and its actual characteristics may be readily obtained from the results obtained from an actual test on a typical Diesel engina doing actual work. This test was conducted by A. C. Scott, Ph.D., of the Scott Engineering Company, Dallas, Texas, on a 225 horse-power Diesel engine; the following data and curves have been obtained, which will give an excellent idea of the applicability of this engine to the generating of power.

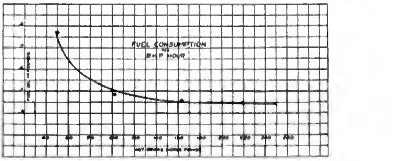


Fig. 1.

The engine built for the Hugo, Okla., Ice & Light Company, by the Busch-Sulzer Bros., Diesel Company, operates on the four-stroke cycle "Diesel" principle. It is a vertical three-cylinder unit, rated at 225 net B. H. P., with allowance for power necessary to drive auxiliaries. It is directly connected to a Fort Wayne 200 K. V. A. three-phase, sixty-cycle, 2,300-volt generator of 164 revolutions per minute. The auxiliaries consist of one belt driver, three-stage air compressor; one motor for driving compressor, 25 horse-power; and one exciter, 10 kilowatt, speed 850 revolutions per minute belt driven from the engine.

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* Reproduced from *The Sibley Journal of Engineering.*

In many cases, the air compressors for the starting and injection air for Diesel engines are belted from the crankshaft of the engine; or when the compressor is motor driven, the power is supplied from the generator. During these series of tests, the power for compressor was furnished from an outside source. Therefore, in order to obtain the net available power developed by the engine, readings were taken of the power consumption of the motor driving the compressor and a deduction made from the kilowatt output of the generator. No allowance was made for the efficiency of the motor; so that with the compressor belted to the engine shaft, the fuel consumption per B. H. P. hour would have been less than shown in the results given.

Fuel Oil Used. To obtain the amount of fuel oil consumed by the engine, it was only necessary to weigh the oil fed to the fuel pump, where the amount of oil actually fed to the engine cylinders is automatically controlled by the governor, and varied according to load requirements. For weighing the oil a 15-gallon tank and platform scale were used, and readings were taken at ten minute intervals. A funnel of sufficient capacity was installed in order that a small amount of oil might be stored ahead of the governor, and the weighing tank properly re-filled with oil.

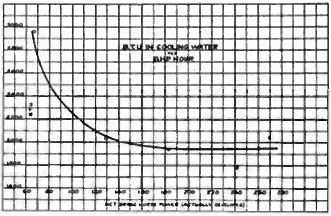


Fig. 2.

The oil used for these tests was taken from regular stock in ordinary use in this engine by the Hugo Ice & Light Company. Samples of oil were taken periodically, and the analysis made upon the total combined sample. The analysis of the fuel oil, made by Drs. H. W. Harper and J. R. Bailey, at the chemical laboratory of the University of Texas, is given below:

British Thermal Units	18,986. per pound of oil.
Specific Gravity (25.5 to 27 deg. Cent.)	0.8531
Viscosity 33.3 deg. Cent. (92 deg. Fahr.)	1.63
Flash Point	143.0 Fahr.
Burning (Fire) Point	181.4 Fahr.
Sulphur	0.2 per cent.
Water	Trace.
Free Acid	None.

The cost of this oil was $1.22 per barrel of 42 gallons, delivered; or practically 2.9 cents per gallon.

The instruments used in making the tests were all calibrated before using and due corrections made in the figures obtained. A water rheostat was found entirely satisfactory for the adjustment of all loads.

Tests. Six tests, each of three hours duration, were made with load changed for each hour period as follows:

Tests Nos	1	2	3	4	5	6
Net Brake Horse-power	2.25	49.7	111.30	162.97	219.63	245.62

Fuel Consumption. The fuel consumption for these various loads was in each instance obtained from an average of the readings taken at ten minute intervals on the generator and the motor, and the records of oil used also taken every ten minutes. Fig. 1 is a curve showing in pounds the fuel oil consumed per net B. H. P. hour at the various loads. Test No. 1 is not included in this curve, as same is practically a no-load test.

This curve was plotted by taking the average readings of kilowatt output of the generator at the switchboard, corrected for the previously ascertained generator efficiency at the given load. From this was subtracted the actual kilowatt in-put to the motor and the resulting figure reduced to B. H. P. It will be noted from the above curve, that the consumption of oil per B. H. P. hour increases but very little when output is decreased from full load to about half load. At full load, the fuel consumed was 0.441 pound per B. H. P. hour, or about 6.2 gallons per hundred net B. H. P. hours. When running at practically half load, the fuel consumed was 0.482 pound per B. H. P. hour, or about 6.8 gallons per hundred net B. H. P. hours. At quarter load, the engine consumed 10.8 gallons of oil per hundred net B. H. P. hours.

Exhaust Gas Samples. Several exhaust gas samples were taken while tests were carried on. Under normal running conditions, water is turned into exhaust valve chambers, this water passing off into the atmosphere as vapor, with the exhaust gas, but whenever a sample of exhaust gas was taken, great care was exercised to shut off the water from the exhaust valve chambers, and sample was not taken until sufficient time had elapsed to insure a dry exhaust. The analyses of these gases were made by Drs. Harper and Bailey, of the University of Texas School of Chemistry, Austin, Texas, and are remarkable in that every one of the samples taken, one of each of the six tests, shows that there were absolutely no illuminants, no carbon monoxide, no hydrogen, to be found in same, thus indicating an absolutely perfect combustion of the fuel oil.

The analyses of these samples of exhaust gases are given in the third column:

ANALYSES OF EXHAUST GASES.

	No. 1 Per cent	No. 2 Per cent	No. 3 Per cent	No. 4 Per cent	No. 5 Per cent	No. 6 Per cent
Carbon dioxide	1.50	3.05	3.92	4.70	6.46	8.40
Oxygen	18.42	16.03	14.95	14.70	9.93	8.93
"Illuminants"	......	......	......	......	......	......
Carbon monoxide	......	......	......	......	......	......
Methane	......	......	......	......	......	......
Hydrogen	......	......	......	......	......	......
Nitrogen and water vapor	80.08	80.92	81.13	80.60	83.61	82.67
Total	100.00	100.00	100.00	100.00	100.00	100.00

SUMMARY OF TESTS.

A summary of these 6 tests is given below:

Number of test	1	2	3	4	5	6
Duration of test hours	3.00	3.00	3.00	3.00	3.00	3.00
K. W. switchboard reading	.....	37.42	80.23	117.5	160	180.1
Comp. motor, gross K. W.	.....	6.9	9.09	8.93	10	11.4
Net K. W. output	.....	30.52	71.14	108.57	150	168.7
Efficiency of generator	.....	85%	87%	90%	92%	92.5%
Net B. H. P. load	2.26	49.7	111.30	162.97	219.63	245.6
Speed, R. P. M.	171.1	169.1	167.4	164.4	164.8	161.9
Pounds cooling water per hour	3187	3037	4875	6300	4537	5175
Jacket inlet temp. F.	61.8	62.4	61.9	62.6	61.7	66.7
Jacket outlet temp. F.	115.3	27.9	115.5	118.9	156.8	173.1
Injection air pressure—atmosphere	39	45.6	56	59	66	77
Fuel oil—pounds per net K. W. hour	.....	1.25	0.7555	0.681	0.646	0.644
Fuel oil—pounds per net B. H. P. hour	.....	0.769	0.482	0.454	0.441	0.444
Fuel oil—gals. per 100 net B. H. P. hour	.....	10.8	6.8	6.4	6.2	6.2
Thermo-dynamic Efficiency (based upon net useful output)	.....	17.4%	27.8%	29.5%	30.3%	30.2%

It will be noted that in some instances there appears to be an excess of oxygen, which is due to the excess of air increasing as the quantity of fuel to be burned diminishes.

Cooling Water Used. The quantity of cooling water used during these series of tests was accurately measured by a water meter, read at 10-minute intervals, and an average taken for each 3-hour test. The temperature of both inlet and outlet water was also read at 10-minute intervals, and from this was obtained the total heat carried away by the cooling water. From these figures a curve (Fig. 2) was plotted, showing the British thermal units carried away in the cooling water per B. H. P. hour.

The points plotted on the above curve were obtained by taking an average of the actual kilowatt output of the generator at the beginning and end of the 15-minute period, from which is subtracted the average kilowatt in-put to motor driving compressor over the same period, so that here again it would have been possible to show better results if the compressor were belted to the engine shaft. The purpose of these tests was to determine what efficiency might be expected under ordinary running conditions, as compared with constant conditions under steady loads. It will be noted that this curve conforms in many ways to the fuel consumption curve for steady loads, in that there is little change in the fuel consumed per kilowatt hour, between half and full load rating of the engine. The figures given on the curve are the readings as taken from switchboard meters, while points are plotted after deduction for the motor has been made.

The recovery of tin from tin-plate waste has become quite an industry. There are three general methods of separating the tin—mechanical, chemical, and electrolytic. The most important of these methods is the last. The electrolyte employed is usually hot caustic soda; loosened chips of tin-plate packed in wire baskets act as anodes, while the iron bath walls or iron plates suspended therein act as cathodes. The average tension is said to be 1.5 volts. When separated the tin is spongiform. Other methods of electrolytic de-tinning are in use in Germany, among them an alkaline method which is said to offer great advantages over the acid methods formerly used, and a chloride method applied by Lambotte of Brussels; this is the most extensively used. The principal requirements for the successful application of it are absolute exclusion of moisture during the process of de-tinning, the avoidance of an unduly high temperature, and proper washing of the de-tinned waste.

Everything in a new pigsty outside Randers, Denmark, which has two stories, and accommodates 1,500 animals, is worked by electricity. There are railway lines all over the sty, and only three men are needed to do the work, which includes grinding corn and fetching milk, foodstuffs, and young pigs from Randers.

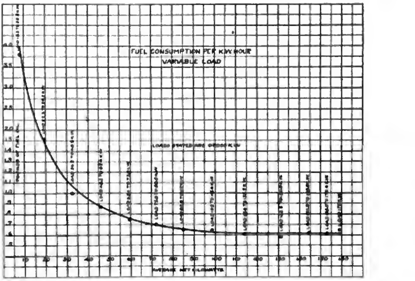
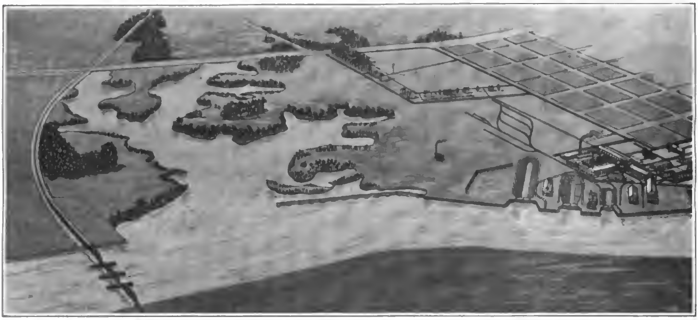


Fig. 3.



View of the undeveloped Schmoele tract to which the Doyle board proposes to apply its plan of development for the extension of the Norfolk navy yard. This tract is two hundred and seventy-two acres in extent, is about a mile long and about three quarters of a mile wide. To the right of the picture is shown a part of the present navy yard.

Proposed Enlargement of the Norfolk Navy Yard

Creating a Great Central Naval Station for Outfitting, Building, and Repairs

THE Naval Affairs Committee in Congress now has before it for consideration the plan of the Doyle board for the improvement of the Norfolk navy yard. This plan, which was conceived by Civil Engineer L. M. Cox, U. S. N., after three years of close application and study, provides the most ambitious system of drydocks, building ways, coaling equipment, and other handling machinery for naval vessels that has ever been suggested in this country.

The plan is purely suggestive. It gives in a graphic outline, with considerable attention to detail, an idea of what can be done at the Norfolk station if the Navy Department and Congress will agree upon a consistent plan of development to extend over a period of from five to ten years with an appropriation of about $15,000,000 scattered through this period.

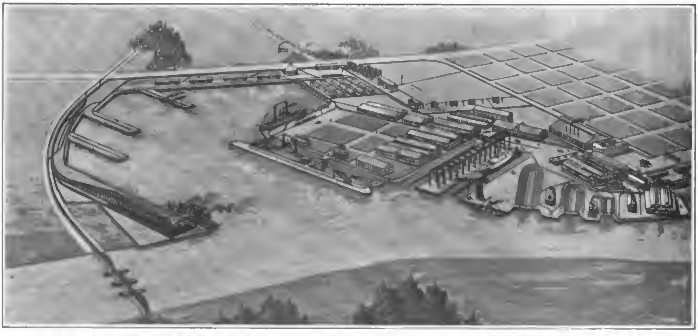
Those who composed the Doyle board are enthusiastic over the plan, and have issued an extensive report to the Secretary of the Navy with drawings and blueprints covering the project in detail, showing facts and figures pertaining to the construction from viewpoints of labor, cost of material, transportation, manufacture, and maintenance.

The central object of interest is the drydock and the Doyle board has applied a scheme of dock building that fits in nicely with the course of the Elizabeth River, being parallel with the stream and open at both ends, equipped so that caissons may be placed at intervals in the dock to accommodate the size of the vessel to be docked, thus reducing to a minimum the amount of pumping or permitting the use of the dock for several vessels without hindering the work on those not ready to be floated.

The new type of dock has been tried abroad with success. If it be introduced here, it will be the only one of its kind on the Western continent. According to the estimate made, it is to cost $3,250,000; is to be 2,500 feet in length net; and will provide space for docking two ships of the Pennsylvania class at the same time. The board has also recommended another drydock (this to cost $1,000,000), which will enable the docking of two more ships, giving a complete docking facility of four dreadnoughts at one time. It is pointed out, however, that the second dock is purely optional and may or may not be built; but the board indicates quite clearly that it will be comparatively easy to construct the additional dock if conditions arise to require it.

The board does not want to be understood as recommending the immediate undertaking of all this work. On the contrary it submits a plan as representing its opinion of the ultimate requirements. As to carrying out the work it makes the following suggestions:

"First year, begin the construction of one drydock,



This is the proposed development of the Norfolk navy yard as outlined by the Doyle board. The plan comprises an immense coaling plant (on left), a double-end drydock, building ways, berthing accommodations for twenty-one first-class battleships, and a complete system of shops, foundries, and storage buildings. The plan is suggested for the Schmoele tract which lies south of the present navy yard. Part of the present yard is shown on the right of picture.

and one building ways; the drydock to be 1,250 feet inside length with a temporary inshore end. This would require about two or three years to complete.

"Second year, begin the construction of ship fitter shop, plate, and angle storage and bending slab.

"Third year, no new work.

"Fourth year, begin dredging and sea wall and carry it to completion on annual estimate of approximately $200,000.

"The other work hereinafter mentioned should be left entirely to future development."

One of the most important features in the report is the recommendations for berthing space that will accommodate the entire Atlantic fleet. The Atlantic fleet at present consists of twenty-one modern battleships, and it is the opinion of the board that berthing space should be provided for the entire fleet as it exists to-day, or for 80 per cent of the fleet units if of the Pennsylvania type.

This will accomplish what no other navy yard now accomplishes. At present, Norfolk can take care of one division of the fleet with comparative comfort. As has been pointed out in the numerous reports of naval experts, the Norfolk navy yard and Hampton Roads is a logical assembling place of battleships and is geographically located so that ships could come in for repairs, and be out on the high sea again in a comparatively short time. The fact that the Norfolk navy yard is but 21 miles from the Atlantic Ocean has been the prime argument for making the Norfolk navy yard a complete naval base.

Another departure from the beaten path is the coaling plant suggested for the extreme southern end of the tract. This plant would have a storage capacity of 200,000 tons of coal, half of which would be stored below the water line. A few hundred feet from the coaling plant are piers for supplying provisions, meats and food-stuffs of all kinds, with railroad connections which feed from the richest territory in Virginia. Further than this it is possible to bring ammunition from the magazine farther up the river to these piers. Mr. Cox stated that with this plan carried out, the Norfolk navy yard could fit out the entire Atlantic fleet ready for "business" in ten days.

As far as building ships is concerned, the recommendation is made that the Norfolk navy yard should ultimately be equipped with provision for building one dreadnaught and one smaller ship at the same time, but that for the immediate future the installation of one ways and building facilities for one ship only of the dreadnought type would be sufficient. The engineers have stated that ships can be built at Norfolk navy yard at a much less cost than the Government is now paying; but in view of the fact that the Norfolk yard is not equipped for building, the first cost would be considerably higher.

The tract, which is known as the Schmoele tract, is located conveniently to belt-line connections with eight railroads. It is in about the same condition as when it was acquired by the Government some years ago. It offers an admirable plan of development, being 272 acres in extent, about a mile long, and, at its widest point, about three quarters of a mile wide. About one third of its area is under water, which will reduce the amount of dredging and excavating considerably, greatly reducing the cost.

The Mechanism of the Spring-Beetle

An Investigation of Its Method of Operation

THE common spring-beetle is an insect barely half an inch long, which, when laid upon its back, rights itself by springing into the air, often to a height of six inches. In most text-books this action is described as follows: The prostrate beetle first concaves its back by withdrawing an appendage of the head segment, known as the "thorn," from its sheath in the thorax, and pressing its point against the rim of the sheath. Then, by a violent muscular effort, the body of the beetle is bent forward, the thorn snapping into its sheath and the now convex back striking the ground with a force that hurls the insect into the air.

That this description is not entirely correct may be proved by dissecting a spring-beetle, and also by examining with a lens the insect as it lies on its back. This has been done by Dr. Otto Thilo, who describes the results and mechanical possibilities as follows in *Umschau*: "A very accurate camera lucida drawing of the large spring-beetle (*Semiotus*), which is about 1.5 inch long, is reproduced in Fig. 1. It will be observed that the back is only slightly hollow between the head segment and the thorax, although the thorn is retracted far from its sheath. This slight concavity vanishes when the point of the thorn touches the rim of the sheath. Hence, the upward spring of the beetle cannot be caused by the sudden reversal of a free-existent curvature. In order to discover the true explanation I investigated a lifeless mechanism, which likewise is hurled aloft by its own power.

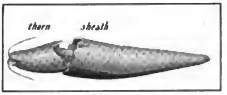


Fig. 1.—A spring-beetle on its back.

"This mechanism is the familiar type of mouse-trap in which a wire, moved by a spring, swings through a semi-circle and strikes the mouse's back (Fig. 2). If the trap is set and one end is slightly raised and let fall, the concussion caused by striking the floor releases the catch, and the wire swings over from *b* to *b'*, striking the wooden base so violently that the trap rebounds vertically and overturns in the air. Here there is no possible reversal of curvature, and the effect is caused solely by a blow on one end of the trap.

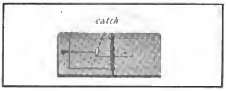


Fig. 2.—The mouse-trap experiment.

"This observation made it seem probable that the spring-beetle is similarly thrown upward by a blow on the anterior end of its body, and this view was confirmed by experiments with a working model of the beetle (Fig. 3). In this model the wire axis of the head is hinged to that of the thorax and abdomen. The two axes are tied together by a cord, which keeps them parallel, but when this cord is burned, the contraction of a rubber band, stretched between the extremities of the head and the abdomen, brings the axis of the head into a position perpendicular to that of the body, and causes it to strike against a fork attached to the thorax, whereupon the whole model springs into the air and overturns, in the direction indicated by the arrow.

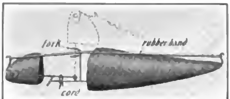


Fig. 3.—Working model of spring-beetle.

"In order to produce a similar action in the living beetle, very powerful muscles and a very flexible joint are requisite. The spring-beetle possesses both, as I have found by microscopic examination. The movement is effected by the contraction of a pair of conspicuously well-developed muscles in the front of the neck, and it is opposed only by a pair of small extensor muscles attached very near the joint at the back. The joint is constructed in a manner which makes it very flexible.

"'The Thorn' is curved like a saber, and its entrance into its smooth curved sheath is made easier by a coat of hair—a device frequently employed to diminish friction in the joints of beetles. We have seen that the thorn does not act as a lock or catch, for it is far from its sheath at the commencement of the action. It serves merely to guide the movement and to prevent dislocation of the neck.

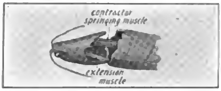


Fig. 4.—Muscles of spring-beetle.

"In conclusion we have to seek the reason of this peculiar action. The explanation is given by experiment. When a spring-beetle is compelled to repeat the act many times, it becomes fatigued and unable to make another spring. Then it endeavors to turn over sidewise, and usually makes many futile efforts before it succeeds in doing so. From this it appears that the beetle adopts the springing movement as the easiest method of regaining its footing. This is the popular opinion, and I find no basis for the doubt that has recently been cast up it."

Track: A Brief History of Railway Rails*

By A. B. Corthell

THE first steel rails made in this country were rolled at Danville, Pa., in 1845. Other rollings were made in the same year by the Boston Iron Works, the Trenton Iron Works, the New England Iron Company, and the Phenix Iron Company. The first Bessemer rail made in the United States was rolled in Chicago in May, 1865; the first Bessemer steel rails to be produced on a commercial order, were rolled in Jamestown, in August, 1867. The introduction of the Bessemer process thoroughly revolutionized the art of rail manufacturing, and the ultimate effect on railway building and commercial development of our country can hardly be overestimated.

Attempts were made about 1870 to roll a combination rail with steel head and iron web and base, but the rapid reduction in price of all-steel rails rendered this process of no economic value, for while steel rails in 1872 sold for $140 per ton, in 1882 the price had dropped to $35 per ton. This cheaper production made possible the heavier rail of recent years, also the larger locomotives, greater capacity cars, and correspondingly greater economy in railroad operations. It is interesting to note in this connection that there seems to have been a fixed relation between the weight of rail in pounds per yard and the weight of locomotives in tons, for when we had 60-pound rails in general use, we had 60-ton locomotives, and with the 100-pound rail, came 100-ton locomotives; roughly speaking, in seventy years the weight of rails has increased 70 pounds, or 1 pound per year.

Not many years ago the designing of rail sections had become a fad. Most engineers were called upon to get up a new standard design, and nearly all roads had their own standard sections. As a matter of record, the rail mills at one time had no less than 188 different patterns and 119 patterns of 37 different weights per yard. The situation was investigated by the American Society of Civil Engineers, and in 1893, after more than three years' deliberation, the society reported upon standard sections for rail from 40 to 100 pounds, varying in weight in 5-pound increments. This report was accepted by the society and recommended to the railroads for adoption during the year 1893. Rails of the above type of sections constituted fully 75 per cent of all the rails rolled in American mills.

In 1901 the report of the American Railway Association recommending the use of 33-foot rails was adopted. In October, 1907, a preliminary report was submitted, accompanied by two series of proposed standard rail sections, and in 1908 the report recommended types A and B. Since October, 1907, several mills have rolled rails substantially in accord with the new sections, both A and B, and it has been demonstrated that these sections can be finished in the mill at a lower temperature than the A. S. C. E. sections. A finer grained and better wearing rail should be secured. However, great care must be exercised in the mills to see that the rails are actually rolled at the lower temperature.

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* Read before the American Society of Mechanical Engineers.

During the year 1913 there has been laid on the Boston & Maine Railroad, 500 tons of 85-pound frictionless rails in curves of 5½ degrees and over, with which it is hoped to lessen materially the flange wear on high rails, which on sharp curves is always considerable. Actual experiment shows that curve resistance is a great deal lessened by the use of this rail. The theory offered for the action of the so-called frictionless rail is based on the means that it allows the outer wheel on each axle to become dominant over the inner one, and the inner wheel to slide laterally to release the outer wheel flanges as they are forced against the outer rail. The outer wheel is traversing a greater distance through a curve than the inner one, but is making the same number of revolutions. On this account, a compensating slide of the outer wheel or a spin of the inner one must occur. The frictionless rail allows this necessary spin to occur at the inside rail.

No subject concerned with track appliances has been more discussed than that of the joint fastening. The evolution of joint fastenings has advanced through three stages: first, the chair which maintains the ends of the rail in alinement and serves as a bearing; second, the fish plate which afforded the rail some support under the head, but greatly improved the matter by stiffening the junction of the rails vertically; and third, the angle bar which combines the features of the fish plate and flange, and effected a great improvement in both the vertical and horizontal stiffness of joint fastening; the plain angle bar is very simple, easily applied, and cheap in first cost.

The conditions which bear some relation to the wear of splice bars are the extent of bearing surface and the hardness of the metal. In the new 85-pound rails and smaller sizes, the question arises whether the plain angle bar meets with the ideal requirements of the splice bar in the two important respects, strength, and the wear in the immediate vicinity of the joint which affects the close union of the parts. We know that angle bars are not strong enough, because they bend and take a permanent set in service, and occasionally one breaks. The supported joints which we have had in use are the Fisher, the Continuous, and the Weber joints.

For bolts to fasten the joints to the rails, the most efficient are those having the so-called grip thread. This bolt is made of a soft steel, and the threads are cold pressed in a manner to upset the metal so as to reduce the diameter of the bolt but slightly at the bottom of the thread. The threads are ratchet shape and undercut 5 degrees on the bearing side. In the nut the bearing side of the thread is at right angles to the axis of the aperture, so that when it is screwed tight against the splice bar the threads of the bolt give to the extent to which they are undercut, and the metal will be pushed completely to the outer recesses of the nut threads, so as to hold the nut against turning off. The nut is square with the corners chamfered next to the wearing surface, which gives an approximately circular bearing. On the bearing side the nut is recessed the depth of a thread and to a diameter somewhat larger than that of the threaded bolt, thus housing and protecting the many threads against injury by the chafing on the splice bar.

The first tie-plates were used to prevent rails from cutting into and destroying the ties. Gradual development has added other features, such as the top shoulder, spike hole, bottom claws, and ribs, all tending to make the tie-plate not only a tie protection, but a more valuable rail brace. Economy of material compels a minimum of weight consistent with strength, and one of the most important considerations is to obtain a tie-plate which will unite firmly with the tie; otherwise it will pound the tie and wear it under rail vibration and afford no lateral resistance to the spreading of the rails. As such a requirement cannot be had by a plate with a smooth underside, practically all tie-plates are now made with under projections in the shape of claws which enter the wood crosswise of the grain, or of the flanged or rib type, which enter the wood longitudinally with the grain. In the former case the lateral displacement of the plate is resisted by an abutment against an end section of the fibers. The standard Boston & Maine tie-plate has four flanges which enter the grain of the tie longitudinally, running the width of the plate. The latest tie-plate shows the two longitudinal flanges and two smaller transverse flanges on the bottom, a heavier shoulder and a better portioning of material.

Wooden ties have been almost universally used by the railroads of this country, and are still used as best practice. Steel ties and ties of concrete construction have been made and are used to some extent with varying success. For wooden ties, the hard wood tie of oak, chestnut, and hard pine are used mostly for main line traffic, and the softer woods, such as cedar, for branch lines of light service. The standard Boston & Maine tie is 6 inches thick by 8 inches wide, and 8 feet long. The average life of a chestnut tie is seven years, and hard pine ties eleven years. The life of a tie can be lengthened by the use of tie-plates and preservatives.

I can see no radical change in the present track materials or methods in the immediate future. The rail may be heavier, and more spikes, tie-plates, and braces added, but the general design will be the same. The changes in turnouts and yards will be most marked; longer switch leads, wider spacings of track, heavier rail, and more careful maintenance are already necessary in a great number of our yards, due to the increased loads in power and rolling stock. In the Pennsylvania Terminal, in New York city, we find part of the tracks laid on stone ballast and some part on a solid concrete base, with creosoted ties bedded therein and anchored by bolts to the concrete, forming a very permanent construction.

Experimental Determination of the Earth's Elastic Properties*

Apparatus and Methods Used in this Intricate Investigation

By Prof. Henry G. Gale

It is well known that the ocean tides are caused by the differences in the attraction of the sun and moon for the surface and center of the earth. These differential forces are very small compared with the attraction of the earth for bodies on its surface: in round numbers the joint tidal force of the sun and moon on a body at the earth's surface under the most favorable circumstances amounts to only about 1/10,000,000 of the weight of the body. This force would deflect the bob of a plumb line 10 feet long from its normal position only about 1/100,000 of an inch. This deviation corresponds to an angle of only 0.02 inch, or the angle which the head of a pin would subtend at a distance of ten miles.

If the earth were a perfectly fluid mass, i. e., if it offered no resistance, either elastic or viscous, to changes of shape, the surface would be tilted by the tidal forces through this same angle, and the new horizontal would be perpendicular to the new vertical. There would therefore be no change of the plumb-line relative to the earth's surface, and we could not detect the so-called "deflection of the vertical."

If the earth were perfectly rigid the plumb line would move back and forth, as the positions of the sun and moon vary, by an amount which can be calculated with an accuracy which is limited only by our knowledge of the masses and relative positions of the sun, earth, and moon. As a matter of fact, the earth is partially and not entirely rigid, and therefore the excursions of the plumb-line are a certain fractional part of the full computed value. After this fraction has been found by experiment, it is possible to compute the rigidity of the earth.

In 1879 George and Horace Darwin, at Cambridge, England, attempted to measure the rigidity of the earth. They used a heavy pendulum whose motions were greatly magnified by suspending a small mirror by two fibers very close together, one of which was fastened to the pendulum bob, and the other to a rigid support. However, even with this extremely sensitive apparatus they were unable to separate any movements due to the moon's attraction from the multitude of disturbing displacements caused by changes of temperature, earth tremors, etc.

Of these disturbing elements, a very serious one is the distortion of the land caused by the immense weight of water periodically thrown upon the coasts in the ocean tides. As late as 1898 Sir George Darwin said that he doubted if it would ever be possible to isolate the effects of the tidal forces from the multitudinous disturbances of a more or less accidental character, although he recognized a possibility in the work of Paschwitz and his successor Ehlert, at Strassburg. They had already secured encouraging results by the use of the horizontal pendulum, which is in effect an exceedingly sensitive adaptation of the plumb-line.

Since then measurements of this sort have been carried out by von Rebeur, Kortazzi, Hecker, Orloff, and others. The experimental results are so obscured by accidental disturbances, however, that their interpretation is difficult, and the results of these various observers differ widely.

In recent years Prof. T. C. Chamberlin has been much interested in the possible effect of the earth tides on the ocean tides, and he and Prof. F. R. Moulton have for years been anxious to secure some definite data on the plasticity of the earth, on account of its vital bearing on questions of planetary evolution. It was through them that Prof. Michelson became interested in the problem of measuring the elastic properties of the earth and designed the experiments which were conducted last autumn on the grounds of the Yerkes Observatory, at Williams Bay, Wisconsin. These experiments are described in full, with graphs and tables of observations, in the *Journal of Geology* and in the *Astrophysical Journal*, for March, 1914.

Prof. Michelson's idea was to substitute a long horizontal water surface for a long pendulum, and measure the changes of level at its ends. There are many advantages in this arrangement. The length may be increased to any desired extent. The water column may be entirely under ground, and thus, to a very large extent, freed from temperature disturbances. Earth tremors produce but little, if any, effect.

The arrangement actually used was as follows: An iron pipe, 500 feet long and 6 inches in diameter, was buried in a trench 6 feet deep along an accurately determined east and west line. At each end there was a pit 10 feet deep and 8 feet square, walled with concrete. The pipe was leveled, certainly to within one half inch, and probably to within one quarter of an inch, and half filled with water. A gage at each end was connected at the top to the air space in the pipe, and at the bottom to the water. A needle point in each gage was brought up from below until it nearly touched the surface of the water. The needle point was illuminated through a window in one side of the gage by a small electric flashlight. The under surface of the water formed a very perfect mirror, and the distance between the pointer and its totally reflected image was read, through a second window, with a micrometer microscope. Gages, pipes, and windows were all air-tight, so that fluctuations in barometric height at the ends were without effect. If the gage at one end was open, the image at the other was not steady, but when both ends were closed, the reflected image was as steady and sharp as the pointer itself. Microscopes were used for which a millimeter at the focus corresponded to about seventeen revolutions of the micrometer head. Observations were taken by measuring the distance between the pointer and its image at one end of the pipe, and subtracting the corresponding difference at the other end. As the water moved, e. g., toward the east end of the pipe, in response to the tidal forces, the difference (E) at the east end increased, since the water was rising higher above the pointer, and the difference (W) at the west end diminished as the water fell there. The difference $E-W$ therefore increased from hour to hour. When the water moved toward the west end of the pipe, the difference (E) decreased and (W) increased, and $E-W$ diminished. The values of $E-W$ plotted as ordinates against the time as abscissas, gave curves which represented the observed tides. Since the water moved down at one end and up at the other, and since the reflected images moved twice as far as the water surfaces, a fourfold magnification was secured. Moreover, since any change in level which might be caused by small changes in temperature or leaking altered the level at both ends alike, the errors caused by such disturbances disappeared in the double different $E-W$. Changes in level due to the settling of the pipe between the ends were also without effect. If, however, one end settled more than the other, the double difference would increase or decrease, depending on whether the east or west end settled more rapidly, and the whole curve would be given an upward or downward slope. A similar effect would also occur if there were an appreciable change in the slope of the rock strata. But since such changes were not periodic, they would not affect the result seriously.

About eighteen or twenty readings per day, at intervals of from one to three or four hours, were taken during August, and it became evident that the method was capable of yielding very accurate results. A similar line was therefore installed in a N-S. direction.

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During October and November readings were taken by the writer on both the N.-S. and E.-W. lines, with the assistance of Mr. Horace Alden of the Yerkes Observatory staff. Readings were taken once an hour from 6 A. M. to 12 P. M. and once in two hours from 12 P. M. to 6 A. M. About four minutes usually elapsed between readings at one end of a line and the other. The mean time of the two was taken as the time of the observation. The result was the same as if the two ends had been read simultaneously at the mean time. The observations began at 8 A. M., September 27th, and ended at 2 P. M., November 29th, 1913.

The curves representing the tides in both the E.-W. and N.-S. pipes were very satisfactory. They showed with great faithfulness tides of the expected form, including the diurnal inequality, and spring and neap tides. The actual change of level at each end at spring tide amounted to about 0.001 inch.

But securing these observations was not all of the problem. It was necessary to know what the tides in the pipes would have been if the earth were absolutely rigid. Computations to determine them were made by Mr. W. L. Hart under the direction of Prof. F. R. Moulton. The tidal forces acting on the water in the pipes depend on the positions of the sun and moon relative to the observer. These positions change in a very complicated manner. In the first place, the moon rises in the east and travels westward across the sky because of the earth's rotation. The moon has a motion eastward among the stars, completing a revolution around the earth in a month. Besides this eastward motion, it makes each month an excursion from 28 degrees (at the present time) north of the celestial equator to 28 degrees south of the celestial equator. Its distance from the earth varies by about 10 per cent during the month, and its eastward motion among the stars is far from being uniform. In addition to all these things the attraction of the sun on the moon causes its motion to be more irregular than it would otherwise be, and it never moves around the earth twice in the same orbit. When all of these complex changes are properly compounded with the almost equally complex ones coming from the sun, the variations in the actual tidal forces are obtained.

Fortunately the Ephemeris gives us the positions and distance of the moon and sun for every hour, thus saving an enormous amount of computation. Even with this aid the work of computing the tides in the pipes was very great. As the experiment progressed and the order of accuracy in the observations was seen to be high, it became necessary to increase the rigor of the computations. It was found necessary, for example, to take account of the fact that the tidal force of the moon is greater on the side of the earth next to the moon than on the opposite side. This refinement has not heretofore been necessary in work on the tides, but it introduces differences of as much as 3 per cent. In its final form Prof. Moulton's formula, including harmonics of the third order, took account of all factors which affected the result by as much as 1 per cent, the probable accuracy of the experimental work.

In comparing the observed and computed tides in the E.-W. pipe, Prof. Michelson found that if the computed tides were multiplied by the factor 7/10 they agreed almost perfectly with the observed ones. But the computed tides for the N.-S. pipe had to be reduced to about one half of the computed values to give the best agreement with the observations. Sample curves for the E.-W. line are given in Fig. 1, and the final mean values of the semi-daily lunar tide for both lines are given in Figs. 2 and 3. The values of the ratios finally adopted were:

E.-W.	0.710
N.-S.	0.523

These figures mean that the water tide in the E.-W. pipe was only 71 per cent of what it would have been if the earth were perfectly rigid, i. e., there is an E.-W. tide in the solid earth which is 290/710 as large as the water tide. In a N.-S. direction there is an earth tide 477/523 as great as the water tide. That is, the earth yields more readily to distorting forces in the N.-S. direction than in the E.-W. direction. Twice each day the surface of the solid earth rises and falls about a foot.

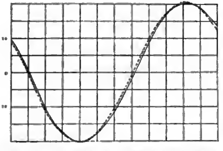


Fig. 2.—E.-W. Mean of all observations, semi-daily lunar tide. Dotted curve, observed values; full curve, 0.7 of calculated.

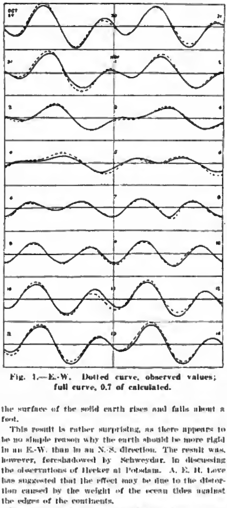


Fig. 1.—E.-W. Dotted curve, observed values; full curve, 0.7 of calculated.

This result is rather surprising, as there appears to be no simple reason why the earth should be more rigid in an E.-W. than in an N.-S. direction. The result was, however, foreshadowed by Schweydar, in discussing the observations of Hecker at Potsdam. A. E. H. Love has suggested that the effect may be due to the distortion caused by the weight of the ocean tides against the edges of the continents.

The times of high tides along the seacoasts with reference to the moon's position are, of course, very irregular, but if these enormous masses of water were flung against the coasts at the time they were due to rise in obedience to the moon's attractions, there can be little doubt that the effect would be to reduce appreciably the east and west earth tides, and thus to increase the apparent rigidity of the earth in this direction. But the ocean tides are so very complex that there appears to be little prospect of making accurate calculations on this point at present.

Added significance is given to the possibility that the ocean tides are responsible for the difference between the E.-W. and N.-S. rigidity by a consideration of the daily, instead of the semi-daily, tide. In reducing the observations Prof. Michelson found that if he considered the tide of period 25.812 hours instead of the semi-daily tide, the ratios of observed to computed amplitudes were:

E.-W.	0.72
N.-S.	0.66

The agreement here is much better than for the semi-daily tides, but as Prof. Michelson has said, if the Love-Schweydar theory is correct, we would have expected a considerable increase in the E.-W. ratio, when the disturbing effect of the ocean tides was eliminated.

Of no less importance than the ratio of the observed to the computed amplitudes is the question of their agreement in phase. It was found that the maxima and minima of the observed and computed tides occurred almost exactly simultaneously. The difference in phase furnishes a measure of the plasticity of viscosity of the earth. If there is no difference in phase between the observed and computed tides, the distortion of the earth does not lag behind the tidal forces, i. e., for any given value of the force the distortion does not tend to increase with the time. If there were a lag in the earth tide, it would throw the observed water tides ahead of the computed ones. This is rendered obvious at once by an appropriate graph. In the reduction of the observations, Prof. Michelson found that the N.-S. tides were behind the computed ones, in the mean, by about 24 seconds. This lag could have no physical meaning, and the amount is well within the limits of observational error. In the E.-W. pipe the reduction shows an acceleration of 3.6 minutes. This may be a real acceleration, but the quantity is not far from the limit of accuracy of the observations, and it is too small to be regarded as highly accurate.

The agreement of phase between the observed and computed waves is of great importance for the theories of planetary evolution. Darwin's theory of planetary fission, i. e., the breaking off of the moon from the earth and its subsequent withdrawal to its present distance, is based on the assumption that tides exist in the solid masses, which are of a viscous and not an elastic character. If tides are raised in a viscous body the protuberances are carried past the line joining the centers of the bodies and the differential pull on the protuberances acts as a brake on the motions of the system. The resulting effect is to slow down the rate of rotation and increase the distance between the two bodies. The tidal theory of the evolution of the moon depends chiefly on the assumption that such tides exist in the earth. The results of this experiment show that the earth-moon system has not undergone the evolution supposed by Darwin unless the interior conditions were formerly vastly different from what they are at present.

Prof. Moulton's calculations show that if the ratio of the observed to the calculated tides is taken as 0.70 and the acceleration of phase as the mean of the E.-W. and N.-S., i. e., 1.8 minutes, the mean rigidity of the earth is about 8.6×10^{11}, and the viscosity is 10.9×10^{16}, in C.G.S. units. These are of the order of magnitude of the rigidity and viscosity of steel. These calculations assume that the distortion decreases in geometrical progression as the time increases in arithmetical progression, and that the substance of the earth is homogeneous, a condition which does not, of course, exist. We may say, however, that the earth tides are approximately what they would be if the earth, through and through, had the properties of ordinary steel.

It would be a matter of very great interest to have similar series of observations taken at various places on the earth. Prof. Chamberlin is very hopeful that the whole problem of ocean tides, now so intricate and apparently insolvable, may yield to investigations conducted along lines which take account of the joint action of the water tide and body tide. There can be no doubt, as he has pointed out, that the tides in many places are largely influenced by the rocking of the basins. It would be necessary to conduct a number of investigations like the one herein described in different regions to give definite knowledge of the facts as to the amount of the body tide, together with an ample series of inspections of the basins of the great water bodies. Prof. Chamberlin also believes that we should have further investigations of this kind on account of their bearing on vulcanism and seismic disturbances. These phenomena are almost certainly connected with the elastic state and degree of rigidity of the earth-body and of its different parts.

It is Prof. Michelson's intention to install an automatic recording device, and to continue the observations at Yerkes Observatory by interference methods. A considerably higher degree of precision is expected.

In Turkey, where cement is not used or hardly known, a substitute has been found that has met with rather good results when applied in exposed places, in filling crevices in water pipes, covering joints in stone floors, in fountains and for numerous other purposes where cement would be required. The mixture is as satisfactory in water as in exposed places, but it must be allowed to become thoroughly dry before it is submerged. The mixture is slaked lime, linseed oil, and cotton fiber. Generally a hollowed-out stone is used, although a flat, hard surface will answer, and the process is started by pouring the oil on a handful of cotton, after which the lime is dusted in. It is then kneaded until the whole is thoroughly mixed and about the consistency of dough. The more it is kneaded the better it becomes.

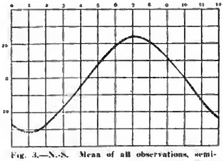
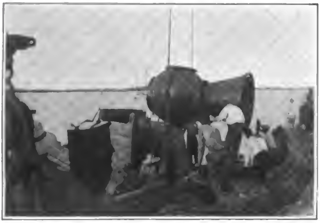


Fig. 3.—N.-S. Mean of all observations, semi-daily lunar tide. Dotted curve, observed values; full curve, 0.5 of calculated.



The working chamber from which the pictures were taken.

On board the working barge. The operator about to descend.

Moving Pictures Under Water

A New Apparatus for Making Sub-Marine Investigations

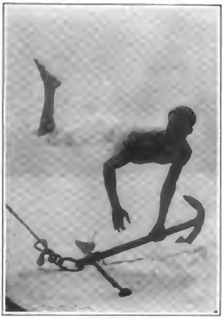
By Keville Glennan

EXCEPT from the lips of divers who have descended on the edges of the coasts to a puny depth of a hundred feet, we are in ignorance of what lies beneath the waves. And the divers, with the limited field of observation accorded them by the crude appliances of their trade, have been able to tell us but little of the nature of things in that vast area beneath the waters which embraces three fourths of the earth's surface.

Now the riddle of the deep is about to be solved. For hours at a time men have sat in comfort fifty or sixty feet beneath the surface, where they have smoked and talked and breathed as naturally as though on shore. And they looked with delight at the wonders and beauties of subaqueous forests; studied the thousands of brightly colored tropical fish; watched with increasing admiration and surprise the panorama afforded by the lacelike lengths of a coral reef, and observed with awe the skeletons of once proud ships as they rested where they disappeared from human ken generations ago.

What these men saw beneath the sea they photographed, and some of the wonderful pictures they secured are here reproduced, giving to the readers of this publication the first authentic motion-picture views ever taken in the depths of the ocean.

While it is true that the greatest depth achieved in these experiments is not greater than that frequently reached by divers, it was demonstrated that a means for deeper trips into the unknown waters has been found, and that the time is not far distant when it will be easy to go down several hundred feet. The apparatus used in the experiments was subjected to a thorough examination at the Norfolk navy yard by officers of the navy, who reported that it would be perfectly safe in its present form of construction at a depth of 800 feet. To make it strong enough to go even deeper is simply a mechanical detail.

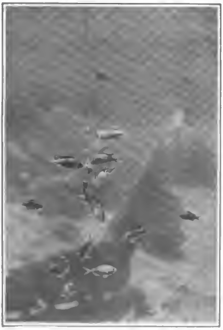


A diver at the bottom of the sea.

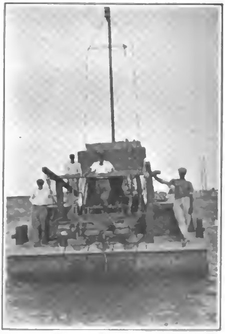
The experiments in the waters of the Bahamas were made to secure a scientific motion-picture film that would show the actual conditions on the bottom of the sea, and the daily habits of the many forms of sea life that abound in the waters of the tropics. Before describing the way in which the photographs were secured an outline of the apparatus used will give an insight into the mechanical features of the experiments.

Several years ago Capt. C. Williamson of Norfolk began working to perfect an invention that would take the place of the ordinary diving suit. It was his idea that some means should be developed by which a man could go down into the water unhampered by weights, ropes, compressed air, or water pressure. Broadly considered, his apparatus is in three parts: (1) a floating vessel of any suitable design; (2) a submersible terminal operating chamber in which work or observations can be carried on at the bottom of the water; and (3) a collapsible, flexible tube of metal connecting the floating vessel and the submersible chamber.

The main feature of the invention is the tube which is made of steel sections of varying lengths. Each section has an upper and lower flange and these are connected by a set of steel hinges, so arranged as to open and shut along radial lines to the axis of the tube, but at all times to fit against each other so closely as to be water-tight. Some of the sections have only one set of hinges and when collapsed the flanges rest upon each other. In the longer sections there are several sets of hinges joined to each other between the upper and lower flanges. When collapsed they stand about three feet high, and are eight feet long when extended. The sections can be fitted to each other readily, and the length of the tube thus regulated as required. Because of the collapsible nature of the sections it is possible to easily submerge the tube. Anyone who has tried to push a large bucket bottom downward into the water will realize what a difficult thing it is to do. With the collapsible tube each section displaces a little less than its own weight in water at the surface when extended; therefore it will sink. But deeper down the pressure of the water overcomes this advantage, when the tube automatically collapses, section by section, from the bottom upward, and as each section closes its weight remains the same, but its volume of displacement grows less. By this means the continual adding on of sections at the surface forces down the sections



Fish around a baited hook.



The diving barge.

below. The operating chamber is attached to the bottom section.

The idea of taking submarine motion pictures came to the sons of the inventor while watching the projection of a scientific film showing fish swimming in a small glass aquarium tank. These two boys, J. Ernest Williamson and George M. Williamson, had worked with their father in the development of the tube, and they at once set about arranging experiments, and in a few weeks had secured excellent snapshots of fish swimming along the bottom of Hampton Roads with an ordinary camera.

Using these photographs as an argument, they formed a corporation for the purpose of making photographic records of the ocean's bottom. So far 20,000 feet of marvelous film pictures have been taken beneath the ocean in the West Indies.

The Williamson boys designed a special chamber for the photographic work and also drew the plans for a vessel from which to lower the tube and chamber. This chamber is a hollow sphere of steel with an inside diameter of 5 feet, and from it a cone of steel 5 feet long and 5 feet in diameter at the large end projects horizontally. This cone penetrates the sphere, and at its small end, where it is 18 inches in diameter, a steel bulkhead is fitted. In this bulkhead there are two glass ports, 3 inches in diameter, placed one above the other, which are the eyes of the photographer and the camera. The large end of the cone is closed by a piece of plate glass 1½ inches thick, which was manufactured in Germany especially for the purpose, and is optically flawless.

To protect this glass from the pressure of the water, gages and pumps were installed in the sphere. One gage shows the water pressure against the outside of the glass. The other shows the air pressure within the cone, and the pump is used to equalize these pressures. In the sphere the air is the same as that above the water, and the photographer works under the same conditions he would experience were he photographing the inside of a building.

It was the original intention that the first pictures be taken on the Pacific Coast, but upon the advice of Dr. Townsend, curator of the New York Aquarium, the Bahama Islands were selected as being richest in varied forms of marine life and variegated corals, and the waters of unexcelled clearness.

The first film was made in the celebrated Marine Gardens at a depth varying from fifteen to twenty-five feet. These gardens are in a narrow strait between Hog and Athol Islands, and as a strong current of about seven knots an hour is constantly running through this channel, it was just the place to give the tube a severe test at the very beginning of the work, and the result was eminently satisfactory. By mooring the barge to four anchors across the tide, and then slacking the cables on one side and taking in those on the other, it was possible to swing with the tide while Mr. Gregory, down in the chamber, turned the crank of his camera and photographed a panorama of sea bottom wonderful in the luxuriant growth that makes the Marine Gardens so beautiful and unlike anything that can be found above the surface of the waters. The clearness of the water and the perfect illumination afforded by the sunlight coming through it and striking the white coral bottom was remarkable, and in the deep recesses of the coral caverns it was not unusual to secure perfectly exposed negatives at 1/75th of a second with a lens opening of f6.3.

Not only are the Marine Gardens there more beautiful than any in this part of the world, but there are many wrecks strewn along the treacherous coral reefs which extend for miles along these islands, for here in the old days many a Spanish galleon and treasure ship and many a Spanish conquistadore came to grief.

In the shipyard at Nassau the Williamson boys had constructed a barge about forty feet by eighteen wide, in which was built a well of sufficient size to permit of the passing of the observation chamber, which was handled by chain hoists.

The Williamson brothers took charge of the entire outfit and its operation, but they secured Carl L. Gregory, an expert photographer, to make the first photographic film ever taken beneath the ocean, and to these three young men is due the wonderful success of the undertaking.

Photographing under and through water presents many new problems, as density and light values had to be studied carefully to insure proper focus and exposure. But prior to starting work with the camera Mr. Gregory and the writer prospected the waters near Nassau with a glass-bottomed boat, buoying locations of unusual beauty as well as a number of old wrecks lying on the sharp coral reefs, and several deep caverns that were inhabited by thousands of brightly colored fish.

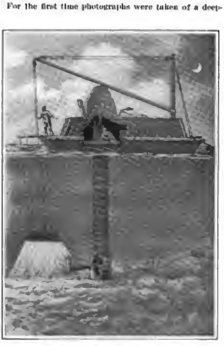
The barge was named the "Jules Verne," in honor of the writer whose imagination saw what the camera has now revealed, and it was a coincidence that the powerboat that towed it was named the "Nautilus." Superstitious ones at once decided it to be a good omen.

When looking down into the water by means of a water-glass the vegetation at the sea bottom is much foreshortened, and the greatest height is, seemingly, about three feet. Through the glass of the chamber, however, the beautiful ferns, sea palms, and other species of subaqueous growth are seen in their full dignity as they wave and sway in the tide to a height of eight or ten feet.

Hulk of a sunken blockade runner.

Diver preparing to descend in an ordinary diving suit.

For the first time photographs were taken of a deep-sea diver working on a wreck. Near Nassau there is the hulk of an old blockade runner that came to grief during the Civil War, lying at a depth of fifty feet; and scattered on the bottom near her are some rust-encrusted cannon and many cannon balls. George Williamson volunteered to be a diver, and although he had never been beneath the surface in this sort of garb before, he gamely went down and strolled about the wreck, picking up cannon balls and sending them aloft in a wire basket attached to a line, and while so engaged, Mr. Gregory, safe and dry in the chamber, was photographing him.



How the pictures were taken.

Another interesting film was made to show the entire workings of the sponge industry. The fleet of a hundred or more sponge schooners was filmed at the quay in Nassau. The barge was then towed out to the sponge bottoms, and the chamber lowered where a full view of the sponges could be had. Instead of diving, the spongers use a bucket with a glass bottom, through which they can look down into the water. When they see a sponge they push down a long pole with two iron hooks on its end, twist the hooks into the roots of the sponge and pull it from its bed on the bottom. This process was photographed, both below the water and on the deck of the sponge boat, and the marketing and trimming of the sponges on shore followed.

Many feet of film were made of the hundreds of different kinds of fish that abound in the Bahama waters. Some were caught as they swam about in their natural haunts among the coral reefs, and others were lured close up to the chamber by means of a baited line. Color plates were taken to be used as a guide in coloring the film by hand, so that the world may see in their natural tints the fish, the wrecks, the reefs, and the marine gardens.

As in all tropical waters, the sea around the Bahamas abounds in sharks, and a film was secured of a battle between two of these monsters. Specimens eighteen and twenty feet long are common and no ordinary sized bait would last long enough for the purpose of photographing them.

However, after unwinding many miles of British red tape, for the law does not permit an animal to be wantonly killed no matter how incapable of work it may be, a lame horse was secured and put to death by a special agent from the Police Department, at a convenient place on the shore, from whence it was towed out to sea and anchored in the water near the apparatus. In less than an hour after there were twenty to twenty-five of these huge scavengers of the sea milling around the bait.

Half a dozen of these monsters were caught with large hooks attached to chains, and one of the largest was drawn to the chamber to permit the taking of a good view of his struggles. A portion of the haunch of meat which was used for bait still protruded from his jaws, and while he struggled thus, another huge shark swam in view and wrested it from him. Swallowing this at a gulp, the newcomer swerved away a few feet and then turning with open jaws, darted like an arrow at the fish still imprisoned by the hook. A battle royal followed, each lunging with open mouth, and tearing one another at every available point, but despite the hook which still hung tenaciously to his jaws, the wounded shark beat off his opponent. Every movement of this unique battle is faithfully recorded on the film.

Many stories have been written of hand-to-hand conflicts between men and sharks, but when it comes to finding a native diver who will actually go down armed with nothing but a short knife, and engage in a single-handed combat with one of these brutes, it means considerable more than the exercise of a fertile imagination. Such a man was at last found, and motion pictures made of a naked diver meeting one of these kings of the deep in his own element, and, escaping the yawning jaws as a matador dodges a bull, with one swift thrust quivering steel landing a death stroke in the monster's vitals.

A New Element in the Atmosphere

By F. W. Aston

In his studies on the positive rays, J. J. Thomson obtained indications of the presence in the air of a body of atomic weight about 22 and giving a line next to neon, atomic weight 20. On continuing this work the conclusion is reached that atmospheric neon is a mixture of two gases which are identical in all their properties except their atomic weights, which are, respectively, 19.9 and 22.1. By 3,000 fractionations of the gas, or, better, by using the diffusion method in conjunction with a new quartz-disk density balance in which 0.5 cubic centimeter of the gas is weighed against oxygen, it is found that ordinary neon contains about 12.5 per cent of the heavier gas, which does not appear to be a compound. The spectra of the two gases are apparently identical.—*Engineering.*

The Flying Machine from an Engineering Standpoint—I*

A Review of Recent Progress

By Frederick William Lanchester, M. Inst. C. E.

1. *The Air Considered as the Permanent Way.*—In approaching the subject of the flying machine from the engineering standpoint, it is desirable to devote attention in the first instance to the air considered as the "permanent way." When the atmosphere is quiescent a gliding model or a flying machine curves its way through the air in rectilinear flight as if supported on a perfectly laid track—a far more perfectly laid track than the railway engineer has hitherto shown himself able to lay down. Under such conditions the aeronautical constructor requires to know the weight and coefficient of traction of the machine, the velocity of flight, and the maximum gradient it is required to climb, the problem then resolving itself into the provision of a screw propeller of sufficient diameter and appropriate pitch to supply the necessary thrust reaction, and the fitting of a motive-power engine (and, if necessary, gearing) to drive the said propeller at its correct speed. The horsepower needed is calculated just as in any other case of propulsion or traction. In addition, the engineer needs to be able to calculate the stresses necessary to the design of his aerofoil and fuselage structure, and to design a suitable alighting chassis. For the present, we shall assume that we have to deal with a machine in being, and devote our attention to the peculiarities and properties of the aerial highway to which the machine has to be adapted and to adapt itself. In Fig. 1 is represented the flight path[1] of a hypothetical machine, plotted from a mathematical equation. The hypothetical machine differs from an actual flying machine, or glider, inasmuch as it is assumed to be quite small in comparison to the minimum radius of curvature of its flight path; its whole mass is taken as concentrated at its center of gravity (consequently it has no moment of inertia about its transverse axis), and it is presumed to experience no resistance in flight, or, alternatively, it is supposed to have a propelling force constantly applied equal at every instant to its resistance. Referring to Fig. 1, it is seen that the straight-line flight path is represented by a horizontal line, path No. 1; here the velocity of the machine is equal to that acquired by a body falling freely through a distance H_0 constituting the distance between flight-path No. 1 and the datum line. For this hypothetical machine there is an infinite number of other possible flight paths, the whole series being represented by the equation:

$$\cos\theta = \frac{H}{3\,H_0} + \frac{C}{\sqrt{H}},$$

from which the samples given are plotted.

It will be seen that the series comprises two notable special cases;[2] first, we have the straight-line path No. 1; secondly, the exact semi-circle No. 7.

The flight paths, or "phugoids," Nos. 1 to 6, of less amplitude than the semi-circle, are those which are of chief concern from our present point of view, the cases beyond the semi-circle, in which the curve has no point of inflection, and in which the machine "loops the loop," are in the main only interesting from the point of view of the mathematician and the student of "trick flying." These inflected curves have been more fully plotted in Fig. 2. In both Figs. 1 and 2 the velocity at any point is that corresponding to a body falling freely from the datum line. Thus, given the normal or natural flight velocity V_0, the scale of the chart is determined by the calculation of H_0 from the equation of the falling body,

$$H_0 = \frac{V_0^2}{2g}.$$

Although, as already stated, the flight paths given in Figs. 1 and 2 represent, strictly speaking, a hypothetical machine that only faintly resembles an actual machine, the difference has but little effect on the validity of these flight-path charts. I have shown[3] that in the main the effect of moment of inertia about the transverse axis is to cause the amplitude of the oscillation to increase, so that the machine, or glider, will pass by imperceptible stages from one curve to another in the order they are numbered on the chart, eventually leading to instability. I have also demonstrated that the assumption of a constant horizontal propulsive force, in place of a force always in equilibrium with the resistance, has the reverse effect, and tends to damp out an oscillation and diminish the path amplitude. We may thus in any free-flight model, or glider, have the flight path unstable, neutral, or stable,[4] according to which (if either) influence predominates. In an actual flying machine we may also have the flight path unstable, neutral, or stable; but here experience has shown that a skilled pilot is well able to handle a machine even though its natural flight path may be unstable; in spite of this, calculation shows that, speaking generally, machines as flown to-day are not far, one way or the other, from the neutral state. From the engineer's point of view it is unimportant whether the flight-path stability is inherent in the machine, or whether, so to speak, the finishing touches have to be given by the pilot himself.

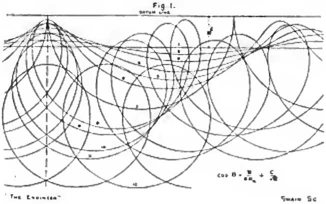
The point I wish to make clear at the present juncture is that the curves, plotted from a mathematical equation, do actually apply with reasonable experimental exactitude to models and to machines in flight. Thus, a disturbance acting on any model in free flight will set up periodic undulations in the flight path, and these have, within the limits of experimental observation, both the time period and phase length corresponding to their theoretical values in relation to the flight velocity. Some experimental determinations,[5] showing the reality of this relation made with models in free flight, are given in Table I.

Table I.

	1	2	3
Flight velocity	14.0	14.0	10.0
Theoretical phase length, feet	27.0	27.0	15.5
Measured phase length, feet	30.0	.....	.....
Theoretical time period, seconds	1.93	1.93	1.53
Measured time period, seconds	1.9	1.83	1.37

The phugoid, or flight-path chart, is capable of useful

Fig. 1.



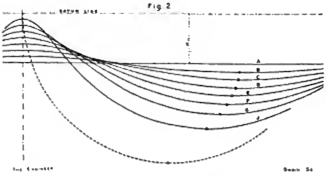


Fig. 3.

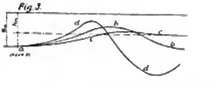


Fig. 4

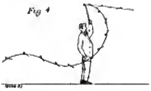


Fig. 5

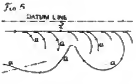


Fig. 6

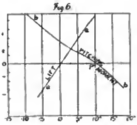


Fig. 7a

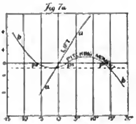
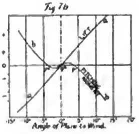


Fig. 7b



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* The James Forrest lecture delivered before the Institution of Civil Engineers on May 5th. Compare also the same author's paper on "Catastrophic Instability in Aeroplanes," Scientific American Supplement, February 14th, 1914, p. 98.

[1] Reproduced from Fig. 42 of "Aerial Flight," by F. W. Lanchester, vol. ii.

[2] There is a further special case when the value of H becomes infinite; the flight path becomes a circle of radius = $2\,H_0$.

[3] "Aerial Flight," vol. ii, § 52 et seq.

[4] This kind of stability is frequently termed "dynamic stability."

[5] Tabulated from "Aerial Flight," vol. ii, § 69.

application in more ways than one. Any movement of the tail-plane or "elevator," for example, by altering the attitude of the main aerofoil causes the machine to become self-supporting at a lower or higher velocity; that is to say, alters its natural velocity, and we thus may represent such a change in the manner indicated in Fig. 3. Here a machine is presumed flying at a certain velocity corresponding to the height H_a, its elevator at the point *a* is altered to correspond to a lower flight velocity corresponding to a height h_a; this is equivalent to altering the scale of the chart at that point, and the subsequent path of the machine is represented by the phugoid curve *ab*. This path may undergo damping, either due to the inherent stability of the flight path, or due to the intervention of the pilot, as shown by the line *ac*. In the case of a model of unstable flight path, with no intervention from the pilot, the flight path becomes one of augmented amplitude, *ad*.

When a machine is fitted with an elevator (or adjustable tail-plate) of large surface, it is possible for the pilot to take such entire charge of his machine that he appears to be designing his own flight-path curves rather than modifying or damping the natural curves of the equation. It is quite true that this is one way to fly; it is, in fact, the old Wright method of flying, the original Wright machines having been furnished with a front elevator carrying little or no load. That type of machine, however, may be regarded as a thing of the past. The Wright machine could be "piled up" by inattention or want of skill at any moment, and if once its flight velocity fell below a certain value, either from want of attention on the part of the pilot, or from a wind-gust from abaft, or other cause, the pilot was definitely unable to restore his normal flight condition; it is for this reason that the Wright type of machine has been abandoned.[4]

2. *Catastrophic Instability.*—Before entirely quitting this branch of the subject, attention will be directed to a point first raised by me within the last twelve months, under the title of "Catastrophic Instability." It is a curious fact that, although the author and other investigators had been studying the question of stability by various methods for some twenty years more or less, and such items as longitudinal stability, lateral stability, and a form known as asymmetric or "rotative" stability, have been "catalogued" and investigated, both theoretically and experimentally, a form of instability which may in practice be far more serious and deadly has until quite recently escaped notice. There are certain types of flight model, of which the ordinary "ballasted plane" is an example, in which the flight path is ambiguous. In the case of the ballasted plane[5] the position is quite simple; this type of model is symmetrical, it has no "upside down"; if launched at its correct flight velocity to travel on flight-path No. 1 (Fig. 1), it is equally capable of traveling on an alternative flight path intermediate to those numbered 11 and 12, the only determining factor being whether at the moment of launching the pressure reaction is in an upward or a downward direction. A very slight want of skill in launching one of these ballasted planes gives at once the inverted flight path (Fig. 4); likewise a gust or disturbance acting on a model of this kind in flight may be sufficient to invert the flight path and determine its downfall. From our present point of view, regarding the air as the "permanent way," the position is as though the model, or machine, were continually crossing a number of facing points arranged, not quite as on a railway, but in a vertical sense (Fig. 5), so that the machine is always in danger of being switched off to an inverted flight path *ae*, if an aerial disturbance of the right kind and sufficient magnitude and duration happen to be encountered.[6]

In my opinion the soundest way to avoid danger from this cause is experiment in a wind channel with scale models, both of the aerofoil and of the machine as a whole, prepared from the working drawings.

According to the evidence that has up to the present been collected, the lift diagram for any machine passes without break of continuity from positive to negative values, and the angle of inclination is a single-valued function of the pressure reaction *aa*, Figs. 6 and 7*a*. The pitching moment in some cases is a curve of similar character, *bb*, Fig. 6, in other cases it is of the form *bb*, Figs. 7*a* and 7*b*, the latter of which represents the case of the ballasted plane. In Fig. 6 the model may be considered as catastrophically stable, but in Figs. 7*a* and 7*b* there is instability; there are three positions, or attitudes, of the machine at which the pitching moment is zero, the two outer two, p_1 and p_3, defining, respectively, the stable positions of normal and upside-down flight, and p_2 marking the critical angle of unstable equilibrium when the machine passes from one state to the other.

In Table II are given results of some experiments recently carried out with a model machine at the National Physical Laboratory. These were not directed to the point in question, but incidentally serve as an apt illustration, and roughly from the basis of the plotting, Fig. 7*a*.

TABLE II.

Angle of Pitch.	Pitching Moment.	
chord as datum		
−14	+0.0201	
−12	+0.0152	
−10	+0.0068	< Angle of stable equilibrium upside down.
−8	−0.0015	
−6	−0.0059	
−4	−0.0048	
−2	−0.0014	< Critical angle of catastrophic change of flight path.
0	+0.0030	
2	+0.0070	
4	+0.0102	
6	+0.0210	
8	+0.0218	
10	+0.0127	
12	+0.0072	
14	+0.0026	< Angle of stable equilibrium right way up.
16	−0.0043	
18	−0.0173	

In the experimental figures as tabulated, the evidence of catastrophic instability is seen in the column headed pitching moment; whenever there are three changes of sign the model is catastrophically unstable.

(*To be continued.*)

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[4] Practically the whole of the distinctive features of the early Wright machine have disappeared to-day; for example, the tailless machine is a thing of the past, nearly every modern machine is fitted with a tail-plane. The forward elevator is obsolete or nearly so. The twin propeller has given place to the single propeller in almost every case. The gear-driven propeller has also been abandoned. The vertical four-cylinder or motor-car type of engine has proved itself inadequate. The exposed position of the pilot, engine, etc., has gone never to return. The Wright method of launching on runners and alighting on skids also is a thing of the past. The biplane construction of the fore-and-aft vertical surface has to some extent survived, but these features were in no wise new when adopted by the Wright Brothers. The wing warping and vertical rudder (neither feature in itself new), operated by the Wright Brothers from one control lever in common, are nowadays operated from two entirely separate controls.

[5] A rectangular plate of mica, conveniently 0.003 inch thick, 8 inches by 2 inches, ballasted at the center of the leading edge. Compare "Aerial Flight," vol. I, p. 231; vol. II, p. 4.

[6] The disastrous nature of this sudden inversion of the flight path may be gaged from the fact that it represents in effect a complete reversal of gravity, the machine is accelerated downward with a force comparable to that previously giving it support, and any loose tools, instruments, or fitments, including the pilot himself, are liable to be jettisoned by the machine, whose subsequent career is an upside down flight carried out on its own account. The facts on record relating to the fatal accident to Major Merrick at the Central Flying School (October 3rd, 1913) point strongly to catastrophic instability as the cause.

Pressure of Light Measured by Use of Thin Foil

By G. D. West

THE pressure of the radiation emitted by a carbon filament lamp at a distance of a few centimeters is sufficient to cause a microscopically measurable deflection of the end of a suspended strip of gold, or aluminium foil, and by this means the radiation pressure can be calculated if the weight of the strip is known. The results agree to within about 10 per cent with the energy density of radiation as measured by the initial rise of temperature of a copper plate exposed to the radiation. The best results are obtained by working in an atmosphere of hydrogen, at 1 centimeter to 2 centimeters pressure, but good results are obtained with hydrogen at atmospheric pressure. Air at 1 centimeter to 2 centimeters pressure also gives good results. The method involves no laborious adjustments, and the apparatus is not seriously affected by vibration.—*Phys. Soc. Proc.*

Neutralization of Chromic Acid

By L. Margaillan

THE progressive neutralization of chromic acid by sodium hydroxide was followed by the electrometer method, using an electrode of platinum saturated with hydrogen. The E. M. F. curve was interrupted by two almost vertical portions (instead of one, as with sulphuric acid), corresponding respectively to the addition of one and of two equivalents of alkali.—*Comptes Rendus.*

The Lassen Peak Eruptions

Are They a Renewal of Volcanic Activity?

WITH the devastating effects of the San Francisco earthquake still fresh in mind, the eruptions on Lassen Peak, California, are exciting considerable interest, especially on the Pacific Coast. As is well known, a wide area of country that includes portions of California, Oregon, Washington, and Idaho was once a vast volcanic field, and the present eruptions on Lassen, which was once an active volcano, raise the question whether they are of a volcanic nature, and therefore a menace to the surrounding country. So far there do not appear to have been any particularly alarming symptoms; but as J. S. Diller, a prominent geologist, says in a report to the U. S. Geological Survey, Washington, "time alone can tell."

"Mount Rainier and Mount Shasta, the beautiful cones so much in evidence to the traveler on the Pacific Coast north of San Francisco, are now finding an up-to-date rival in Lassen Peak, which is plainly in view from the railroad for many miles in the Sacramento Valley between Redding and Red Bluff. Lassen Peak is the southern end of the Cascade Range, and it stands between the Sierra Nevada on the southeast and the Klamath Mountains on the northwest. Its lavas erupted in past ages reach the Sacramento Valley on the one side and on the other form a part of the vast volcanic field, one of the greatest in the world, that stretches far across California, Oregon, Washington, and Idaho to the Yellowstone National Park.

"Of all portions of the Cascade Range Lassen Peak still retains the largest remnant of its once vigorous volcanic energy. Morgan and Supan Hot Springs and Bumpass Hell on the south as well as Hot Springs Valley and the boiling mud-lake Tartarus on the southeast have long attracted the attention not only of Californians but to some extent of the tourists, to whom the region is growing more accessible every year. If to these already established attractions be added a frequent occurrence of the recent volcanic plays of Lassen Peak the region will take high rank among Nature's wonderlands.

"But what is the nature of this new activity of Lassen? Is it really volcanic? Will it soon dwindle and become wholly quiescent, or, on the other hand, is it the precursor of a more profound eruption like that of Krakatoa? The excellent photographs that have been taken of the outburst, from a point six miles northwest of Lassen Peak, leave little doubt in the mind of anyone familiar with volcanic phenomena that the outburst is essentially volcanic. These photographs are strikingly similar to those taken by Johnston-Lavis showing the progress of an eruption in the Lipari Islands, whose volcanic character is well known.

"The eruptions of Lassen Peak began May 30th at 5:30 P. M., with an outburst of steam which, according to Forest Supervisor W. J. Rushing, continued about ten minutes. It formed a crater in the snow-covered summit of Lassen about 25 by 40 feet in extent and covered the encircling snow for a distance of 300 feet with a mantle of dark wet dust. Harvey Abbey, a forest ranger, visited the scene and reported the facts.

"On the following day at 8 A. M., another eruption occurred, and on June 8th, a week later, the third and much larger outbreak took place. It lasted 30 minutes, and the rolling column of dense black smoke rose to the height of 2,500 feet. Stones were hurled from the crater, and the forest service outlook house, a quarter of a mile away on the tip-top of Lassen Peak, was broken by some of them. Blocks and smaller fragments accumulated about the crater to a depth of several feet. The dust and sulphurous gases carried southward by the wind were observed at Mineral, the forestry station, and the dust was noted five miles beyond. Forest rangers who were in the neighborhood of the summit during the eruption heard the rushing steam and the falling rocks, but report no rumbling or subterranean noises, earth shocks, electrical phenomena, or great heat beyond that of steam. The dust was practically cold when it fell. Considerable volumes of water were ejected, probably wholly in the form of steam. The water condensing from this steam washed a gully in the snow to the adjacent lakelet which occupies what prior to this latest eruption had long been regarded as the youngest crater of the Lassen volcano. The new crater is not quite over the throat of the old, but is a few hundred feet to the northwestward.

"In all there have been eleven eruptions up to the date of this report—June 21st. The most violent was at 9 A. M., June 14th, when several over-venturesome persons were injured by falling or rolling stones. The eruption was visible from the Sacramento Valley, nearly forty miles away, and created profound interest. The subsequent eruption on Friday, June 19th, was of relatively small energy. Eruptions were generally preceded by a cessation of escaping steam.

"With successive eruptions the new crater is enlarging. June 20th, when Mr. R. E. Loomis and I visited it, it was 400 feet long and 100 feet wide, with a depth of not over 100 feet. It appears to follow a fissure running a little north of east and south of west.

"The other hot holes about Lassen Peak as far as I can learn have not increased their activity, unless it is Bumpass Hell, which is always fuming; but nothing like an eruption has been reported.

"No definite molten products have been found in connection with the recent eruptions of Lassen Peak. The ejected dust, as far as can be judged from an examination with a small pocket lens, is disintegrated or pulverized dacite, perhaps in part decomposed. The quartz and, apparently, also the glassy feldspar are bright, but the hornblende, augite, and mica are of course not so abundant in the dacite and are less evident. An examination with a petrographic microscope confirms the conclusion that the dust is the product of the pulverizing action of the explosive gases on the rocks through which they are escaping, and not the result of the explosive expansion of gases in a liquid lava.

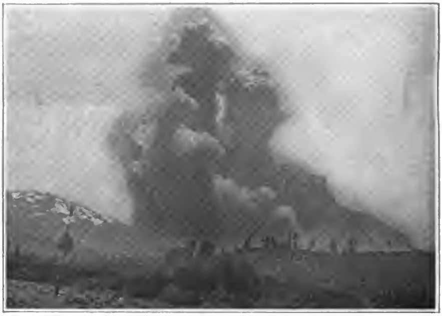
"That heat has recently risen in the core of Lassen Peak is evident from the fact that whereas it was once cold, now it is hot and steaming. When E. E. Hayden and I were on the mountain in July, 1883, and slid down the 2,000-foot snow bank into Hat Creek on our way to Yellow Butte there was no sign of heat in the summit of Lassen Peak. The rocky summit of the peak, struck by many thunder-bolts during storms and superficially fused here and there by the lightning to fulgurite, is still as it was then, and the little lake is there as in 1883; but the heat and the crater are new. Mr. Rushing tells me that these new features appeared with the first eruption. But the fact that the other hot places about the mountain are not yet perceptibly hotter indicates that the rise of temperature is local and does not at least as yet affect the mountain mass. Time alone can tell what Lassen is going to do. The volcano may subside to its former quiescence. But we must not forget that it was only the top of the old Vesuvius that was blown off to make Monte Somma and the Vesuvius of to-day. Krakatoa blew up from the very base with tremendous effect. There seems no good reason at present to fear a Krakatoan outbreak at Lassen Peak, but the part of wisdom dictates a close watch."

On June 16th W. H. Wright, a mining engineer of San Francisco, visited this region and ascended the peak, and the following extracts from his personal observations, published in the *Engineering and Mining Journal*, give additional facts of interest.

"We visited the peak on June 16th, under guidance of Harry Kaul, who had spent the winter at Drake's Springs as caretaker. Kaul stated that on Thursday night, May 28th, he heard a rumbling like that of thunder. Upon going out of doors he found the stars shining brightly. Also that on Friday afternoon, at 2:30, a slight earthquake caused the poorly fastened roof of the barn to slide to the ground. This shock was felt in Westwood, twenty-nine miles, and Susanville, fifty-one miles, distant. At this time Kaul was probably the nearest to the mountain of any person in that region. On Saturday, May 30th, the first eruption occurred, although a stage driver reports seeing a vapor rising from the mountain on Friday. Two days after the eruption, Kaul accompanied a party to the peak. The crater or fissure was then about half its present size, but general conditions were the same. There was not so much *debris* scattered about, and a small pool occupied a depression in the old crater. Since that time numerous eruptions have taken place, and have all been of the same character.

"Leaving the Western Pacific Railroad at Keddie, we traveled by automobile to Big Meadows, a distance of twenty-six miles, to secure saddle horses. Then a horseback ride of thirty-five miles brought us to Drake's Springs, where the night was spent. This point is seven miles from the summit of the peak.

"About fifteen miles from the mountain, in a direct line, the first sign of volcanic dust was seen. A slight film covered the ground. This seemed to lie in a narrow belt, as we soon passed through it when our course was changed. At curious times during the ride glimpses of the mountain were caught, and a column of steam was always seen rising high above the summit. At Lee's ranch, in Warner Valley, ten miles from the peak, we witnessed the second eruption of the day. This happened at 7 P. M. and was an impressive spectacle. The setting sun was level with the top of the peak and a little to the left. A column of steam and dust rose to a height of at least 1,500 feet above the mountain top. In appearance it much resembled the dirty white exhaust of a coal-burning locomotive. Although witnesses to this eruption, situated on the west and northwest sides of the mountain, reported that flames were visible, none could be seen from the southeast side. It is more than likely that the swift-rising column of steam reflected the red rays of the setting sun, giving an appearance of fire.



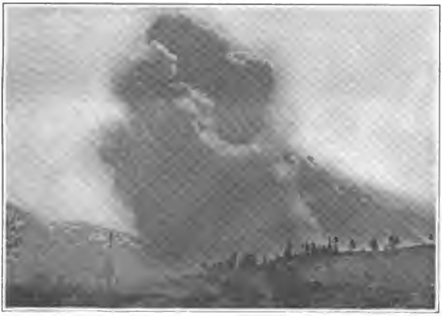
Eruption at 10 A. M., June 14th. Picture taken one minute after explosion.

"The next morning, Monday, June 15th, the party visited Tartarus Lake. This is a pool occupying a crater-like depression, completely surrounded by boiling springs and mud pots. The steam from these has a decided odor of hydrogen sulphide. The area of this pool is approximately an acre. One large spring at the south end is almost a true geyser in its intense bubbling and spouting of steam. Two and one half miles southeast of this lake is Geyser, a large boiling spring, which formerly spouted to a considerable height, but is now quite feeble in its action.

"Two miles northwest of Tartarus Lake, and in the direction of Lassen Peak, is situated the Devil's Kitchen. This consists of a number of solfataras and hot springs that are on both sides of a ravine, through which runs a good-sized mountain stream. Some of the springs actually bubble up through the water of the creek. The action of these springs varies from the sluggish mud-pots to the violently boiling springs that are, in fact, small geysers. The springs after a time apparently become choked with a deposit from the water and form other vents in new places. In the same general line, but a trifle more to the west, Bumpass Springs are situated. This is a group of springs similar to those of the Devil's Kitchen, but on a much larger scale. Many other hot springs, as well as mineral springs, exist in other localities in this region. The steam from all of these springs has the same characteristic odor of hydrogen sulphide, and possibly of the dioxide, although this could not be definitely ascertained by the sense of smell alone.

"Tuesday morning, June 16th, guided by Harry Kaul, the party left Drake's Springs for the summit of Lassen Peak. Kaul had made two trips to the top of the peak since the first eruption of May 30th. The trail leads through a magnificent growth of timber. Above 8,000 feet altitude the traveling was done over hard snow, which as we neared the top became very deep. It easily supported the horses and made the ascent much easier than at other seasons. Even close to the peak only a slight amount of dust covered the snow.

"At 12:30 the ridge at the top was gained and our first view of the crater obtained. The party then descended the slope into the cup-shaped depression that marks the site of the ancient crater. The new crater has broken out on the northwest side of this, and seemingly has been formed by steam escaping under high pressure from a fissure which lies along the main axis of the oval-shaped pit. The steam forced its way through the fissure and formed a narrow crater, the sides of which had begun to cave, rapidly widening it. Pictures were taken at great risk. Aside from the danger of an outbreak of the crater, the danger from the caving sides was great. In order to get good views of the pit it was necessary to go close to the edge. Huge cracks extended back 25 to 30 feet. Every few minutes great masses would fall from the sides. A short time after one of the pictures was obtained, the place



Eruption at 10 A. M., June 14th. Taken 30 seconds after previous view.

Photograph taken one minute after an explosion.

Manzaneta Lake and Lassen Peak.

View taken five minutes after an eruption.

from which it was taken suddenly fell into the hole, sending up a cloud of dust and making a spectacular display, which, unfortunately, was over too soon to be photographed, as the party was busily engaged in eating lunch. The volume of escaping steam varies from moment to moment. In appearance and odor the steam resembles that escaping from the boiling springs previously mentioned; in fact, it was impossible to detect any difference. That the vapor is steam is evidenced by the fact that it condenses and disappears after rising into the air for a short distance. The hole is about 100 feet in width and 500 feet in length, and large quantities of huge rocks were thrown out. The deep snow, on the north slope of the south side of the old crater, which was covered with dust, sand, and rocks, contained several hundred holes which had been caused by falling rocks. These must have been hot, as they were deep in the snow, which is as hard as ice; also, the sides of the holes are perfectly smooth, and there are many large stones lying on top of the snow beside these holes. Of course, it is possible that the unburied ones did not fall from as great a height as those that are buried.

"Small heaps of crumbled rock lying on the snow showed that some of the stones crumbled upon being suddenly cooled by it. At the edge of the crater, *débris* from the different explosions lay on the snow to a depth of three or four feet. This gradually diminished to a depth of 6 inches at the top of the ridge surrounding the cup of the crater. The deposit has been classified as descending from a great height. Upon the snow were stones of various sizes. Next is a deposit of coarse sand, upon which is a layer of very fine dust that closely resembles Portland cement. There was no lava or cinders. The only indications of heat were the hot stones and steam. The mountain is composed of dacite, which has the appearance of gray granite. If one could collect the *débris* from a blast in this rock, he would have exactly the same material that has been cast up by the present eruptions.

"The edges of the fissure are covered with a yellow deposit that appears to be sulphur. This could not be verified, as it was impossible to reach the fissure. An odor of sulphur was noticed in the dust, but it was so faint that it could not be determined whether it was the hydride or dioxide.

"The evidences on the ground bear out the belief that the material thrown out by the outbursts consisted of *débris* from the walls of the ancient crater broken and forced from the fissure by steam under great pressure. Much of this material fell directly back into the new crater or caved from the side, closing the vent and making other explosions necessary to clear the outlet. Lassen Peak is 10,437 feet high and is the southern terminus of the Cascade range. Like many other mountains in this range, it is an extinct crater. In the Lassen lava field, which lies to the northeast and north of Lassen Peak, is situated Cinder Cone, the latest active volcano in the United States. History does not record this last eruption, which appears to have occurred in the neighborhood of two hundred years ago. This eruption was so quiet that it would not attract attention in a sparsely settled country."

The Preservation of Wood—III*

A Synopsis of the Principal Processes in Use To-day

By A. J. Wallis-Tayler

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2013, Page 80, August 1, 1914

The Creo-resinate Process.—This process is used by the United States Wood Preserving Company of New York, and, according to good authority, is a very efficient one for wood paving-blocks. The chief novel feature in the process seems to be the substitution for steam of air raised to a temperature of 121 deg. Cent. (250 deg. Fahr.), and at a pressure of about 100 pounds to the square inch. The air pressure is claimed to prevent the checking of the block, and the air is kept at the same temperature and pressure until the center of the wood being treated reaches a temperature of 100 deg. Cent. (212 deg. Fahr.), at which all germ life, the chief cause of decay, is destroyed. The temperature of the air is then reduced to 65.5 deg. Cent. (150 deg. Fahr.), and subsequently the air is exhausted from the retort and a vacuum of 26 inches is pumped, the charge of antiseptic agent being then inserted. This agent consists of 50 per cent of oil of creosote, 48 per cent of resin, and 2 per cent of formaldehyde. This mixture is forced into the wood under pressure so that the pores are thoroughly impregnated, and 22 pounds per cubic foot are taken up. The wood is next transferred to another retort and treated with a solution of lime, raised to a temperature of 100 deg. Cent. (212 deg. Fahr.) and at a pressure of 150 pounds per square inch. The wood is then allowed to cool gradually.

The Guissani Process.—In this process the wood to be preserved is submerged in a bath of anthracene and pitch raised to about 140 deg. Cent. (284 deg. Fahr.), which temperature is below their boiling-point. Directly, however, the wood is placed in the bath, the mixture commences to boil, and steam and moisture being given off indicate the passing away of a portion of the constituents of the wood. The cessation of the ebullition—which occurs after from 2 to 4 hours—shows that all sap and moisture has been given off from the wood.

The wood is next transferred into a cold bath of heavy oil of tar, in which it is allowed to remain for about 10 minutes, and is afterward placed in a bath of cold chloride of zinc, in which it is kept until the desired amount has been absorbed.

This process also is claimed to be especially suitable for sleepers.

The Saccharine Solution, or "Powellizing" Process.—This process was first introduced by Mr. Powell, and is hence usually termed the "powellizing" process. The exact composition of the solution used is a secret, but it is stated to consist mainly of sugar with a small percentage of arsenic added, and probably several other ingredients.

The value of saccharine solutions for the preservation of wood is said to have been discovered from the fact that the timber of sugar vats is found to be to all intents and purposes everlasting. It is averred that sugar had never been employed for timber preservation before the idea occurred to Mr. Powell, which is probably true so far as treatment on a comparatively large scale is concerned.

The treatment is on the open-tank or immersion system, the treated timber being, however, subsequently subjected to artificial drying. Any description of tank may be used, but a convenient arrangement, especially designed for carrying out the process, comprises a tank of the requisite dimensions fitted with steam-heating pipes and having a water-tight door at one end through which loaded trucks can be run in on a set of tram-lines. The tank having received its charge of timber, this door is closed and cold solution is admitted until the wood is covered. The temperature of the solution is then gradually raised to boiling-point, and kept at that temperature for several hours, the exact time varying in accordance with the dimensions and class of wood being treated. The solution is then permitted to cool down, after which it is run off and the timber is passed on into a drying-chamber in which the temperature is gradually raised until it has been sufficiently desiccated, when it is removed and is ready for use.

The air in the desiccating or drying-chamber is first raised to a temperature of from 55.5 deg. Cent. to 60 deg. Cent. (130 deg. Fahr. to 140 deg. Fahr.), with a humidity of 85-90 per cent, and subsequently this is slowly increased to a maximum of from 74 deg. Cent. to 76.5 deg. Cent. (165 deg. Fahr. to 170 deg. Fahr.), with a humidity of 35 per cent.

An advantage of considerable value possessed by this process is that green wood may be satisfactorily treated.

A microscopical examination of thin sections of wood treated as above, made by Prof. Norman Rudolf, M.Sc., F.I.C., revealed the fact that the cells were swollen up, some being apparently filled with saccharine matter in a non-crystalline form, the saccharine solution having actually become a part of the structure of the wood.

The Vulcanizing or "Haskinizing" Process.—The vulcanizing process, also known as the "haskinizing" process, from the name of its inventor, Col. Haskin, consists in roasting or subjecting the wood, which has been previously dried by steaming, to a temperature sufficiently high to coagulate the albumens contained in it, and in conjunction with pressure also to form new substances. In other words, the high temperature produces a resolution of the woody fiber and sap, and results in the production of wood creosote.

Albuminous food being essential to the life of both fungi and insects, an alteration in the condition of these albumens will render them unfit for the service of the destructive agents. The coagulation of albumens takes place between 71 deg. and 94 deg. Cent. (160 deg. and 201.2 deg. Fahr.).

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* Paper read before the Royal Society of Arts and published in its *Journal*.

An examination of wood treated by the vulcanizing process made by Mr. Chandler, of Columbia College, New York, showed 11.91 per cent of new substances had come into existence, viz., 0.36 per cent of neutral oils and turpines, and 10.78 per cent of resinous acids and other bodies, a large proportion of which consisted of antiseptic and preservative substances.

The plant required comprises one or more air-tight cylinders or retorts, wherein the timber to be treated can be subjected to heating and pressure, an air-compressor, and an air-circulating engine.

The details of the process are briefly as follows: The retort or retorts being charged with wood to be treated, steam is first injected to remove surface moisture from the timber, the moisture thus extracted being drawn off by means of cocks. Air is compressed in the compressor to a pressure of 200 pounds per square inch, the heat of compression being reduced by sparging or spraying with water, and the moist compressed air is dried and raised to a temperature of between 94 deg. Cent. and 204.5 deg. Cent. (201.2 deg. Fahr. and 400 deg. Fahr.), and is forced through the retort by the circulating engine, escaping past a loaded valve, the pressure being kept up by the compressor.

The time required for treatment is from 6 to 10 hours, in accordance with the dimensions of the timber.

This process is more effective in the case of green timber.

The Crésol-calcium Process.—This process, recently brought out by Messrs. F. Friedeman and G. von Heidenstam, consists in the use of an agent composed of a mixture of crésol and milk of lime, the proportions given being 15 grammes of burnt lime (90 per cent to 95 per cent), 40 cubic centimeters of crésol, containing at least 95 per cent of tar-acids, and 500 cubic centimeters of water.

The theory of the inventors is that 2 ounces of creosote per cubic foot is sufficient for purposes of impregnation, the larger quantities ordinarily employed being required owing to the difficulty of insuring even distribution. By mixing crésol with milk of lime they claim to bind the tar-acids by transforming them into salts soluble in water but not volatile. Ordinarily it is impracticable to use tar-acids for impregnation, or to use them in water solutions owing to their being too volatile. It is generally accepted that tar-acids are efficacious agents for timber preservation.

The plant required for carrying out the above process may be any of those ordinarily employed for impregnating timber by the pneumatic methods.

NATURAL OILS AS PRESERVATIVE AGENTS.

Recent experiments have demonstrated that natural oils can be used as preservative agents with a fair amount of success. It does not appear that such oils possess any antiseptic properties, but they serve the purpose of stopping up the open wood cells with a substance which becomes solid under ordinary temperatures, thus preventing heat, moisture, and air from penetrating into the wood, and obviating the assistance which they render to the decay-producing organisms in getting to work. This proposition seems reasonable enough, as it is generally held by timber experts that, in order to produce decay, moisture and heat must be present at the same time with access to the air.

The practice of the Atchison, Topeka and Santa Fé Railway is to use crude Californian oil of a very low specific gravity with about 75 per cent of asphaltum, and the remainder light oils, which vaporize on being heated. The oil is heated to 82 deg. Cent. (179.6 deg. Fahr.) and is forced into the wood at a pressure of from 150 pounds to 200 pounds per square inch. At normal temperatures the oil is of about the consistency of molasses, but when heated it becomes sufficiently fluid to allow of its penetration into the pores of the wood. A slight vacuum is applied at the close of the operation, which seals the pores and admits of the wood being handled without difficulty.

When the process is used for sleepers the amount of oil injected is from 4 to 8 gallons per sleeper, and excellent results are said to be attained as regards the prolongation of the life of the sleepers.

The above railway company, it is said, were induced to experiment with crude oil as a preservative agent owing to finding the life of untreated sleepers to be greatly prolonged on portions of its track on which the oil was sprinkled to keep down the dust. The coating of oil which spread over the tops of the sleepers kept off moisture.

ATLAS PRESERVATIVE SOLUTION.

The composition of this solution is a secret. It is poisonous, and causes irritation of a passing nature on contact with the skin. The treatment of timber with this agent consists in the immersion in a bath of the cold solution of a strength of from 15 to 25 per cent for a period of time dependent upon the size and nature of the wood to be treated. In the case of sleepers from 24 to 36 hours will be required.

After the treated timber is dry, it should, according to the makers, be given a coat of hot gas-tar, probably to prevent leaching.

ANTHROL.

This is a proprietary antiseptic solution, made by the Anthrol Company, which can be used as a paint, or for the immersion or open-tank process. The solution is preferably employed in a heated condition.

BELLIT.

This is also a proprietary solution possessing antiseptic or preservative qualities, and consisting of a 2 per cent solution of dinitro-benzol and mineral oil. It has a boiling-point of 300 deg. Cent. (572 deg. Fahr.). The mode of application is the same as with "Anthrol."

BURNETTIZINE.

Is a preservative solution made by Sir W. Burnett & Co., Ltd. It is used by the Post Office for telegraph poles where creosoting would be undesirable, also by railway, dock, and shipping companies.

This agent is claimed not only to preserve the wood against decay, but to render it practically fireproof as well as strengthening it, and, moreover, to leave it clean and odorless. It is said to enter the heart of the wood and form an insoluble chemical combination that will not wash out.

CARBOLINEUM.

Oils obtained from the distillation of coal-tar consisting of such oils heavier than water, as, with tar-acids, help to form creosote. There are two well-known grades of this oil on the market, carbolineum Avenarius, a preservative solution, introduced over 30 years ago by Mr. Avenarius, and carbolineum "marque de lion."

An analysis made by Dr. Filsinger of the first mentioned (see "Preservation des Bois," Henry) shows it to contain oils distilling at 230 deg. Cent. (446 deg. Fahr.), and to possess a density of 1.128, viscosity at 17 deg. Cent. (62.6 deg. Fahr.), as compared with water 10, to contain 10.6 per cent per volume of oils distilling between 230 deg. Cent. (446 deg. Fahr.), and 270 deg. Cent. (518 deg. Fahr.), and 12.2 per cent of oils coming over between 270 deg. Cent. (518 deg. Fahr.) and 300 deg. Cent. (572 deg. Fahr.). The residue is a thick, limpid red-brown mass.

Carbolineum heated to from 65 deg. Cent. to 94 deg. Cent. (149 deg. Fahr. to 201.2 deg. Fahr.) can be either applied to the wood with a wire brush, or the timber to be treated can be immersed in a bath of the warm solution according to the open-tank method, the best temperature for the bath being 95 deg. Cent. (203 deg. Fahr.), and the timber being allowed to remain in soak 5 to 15 minutes, according to dimensions and character.

Experiments have demonstrated that, in the case of hard woods such as oak and beech, the amounts absorbed by the woods in a bath of carbolineum at a temperature of 60 deg. Cent. (140 deg. Fahr.) were not increased to any appreciable extent by prolonging the immersion to 20 minutes. It also appears that an increase in the temperature of the bath to 80 deg. Cent. (176 deg. Fahr.) and over has no effect upon the amount of the oil absorbed by the wood.

GREEN OIL.

This is a product of creosote, and is used in a similar manner to carbolineum.

HYLINIT.

This preparation is a proprietary article, the composition of which is a secret.

The strength of the solution for treatment by immersion is given by the makers as 5 per cent, and the wood should remain in the bath for 24 hours.

JOBELITE.

Another proprietary antiseptic, used in a similar manner to carbolineum.

The treatment by open-tank method takes from 10 to 40 minutes, in accordance with the density of the wood. The solution should be heated to from 82 deg. Cent. to 94 deg. Cent. (179.6 deg. Fahr. to 201.2 deg. Fahr.).

MICROSOL.

According to an analysis made by Prof. Arth ("Preservation des Bois," Henry), this solution consists of sulphate of copper, 70 per cent, in crystalline and powdered form, sulphate of soda, sulphate of lime, small trace of free silicate, and a copper salt of sulpho-phenol.

The treatment is the same as with carbolineum, the strength of the solution varying from 2 per cent to 4 per cent, and the time required being 24 hours or more immersion, according to the nature, etc., of the wood.

This preparation is well spoken of on the Continent.

SOLIGNUM

A proprietary antiseptic solution made by Major & Co., and applied with a brush, either cold, or, when climate conditions render it advisable, heated to from 71 deg. Cent. to 82 deg. Cent. (160 deg. Fahr. to 180 deg. Fahr.). This solution has a tendency to work downward.

OTHER PROCESSES AND SOLUTIONS.

Among the numerous other processes and patent or proprietary and other preservative solutions, many of which have been used with considerable success, mention may be made of the following: Beaumartin's process for impregnating wood with various metallic salts, on the principle of osmosis produced electrically. According to *L'Electricien*, Paris, 1906, the timber is first placed in a retort, and copper or zinc sulphate, or sodium silicate, is injected under pressure. The wood is then subjected to the action of an alternating current of electricity, by means of which the state of the fibers and the sap, and of the injected salts, is so modified that the last combine with the organic elements of the sap and incrusting matter and form insoluble salts, which remain fixed on the fibers and prevent putrefaction. The alternating currents, moreover, it is claimed, destroy all vegetable and animal germs, and cause the fibers themselves to be so transformed as to increase both their tenacity and their mechanical resistance. Zinc-chloride and sodium-fluoride mixed in equal quantities are recommended by Mr. H. B. Malenkovic; the strength of the solution, which is used according to the open-tank system, is 3.5 per cent $ZnCl$ and 3.5 per cent NaF. For mine timber the United States Forest Service have experimented with (1) a preservative agent consisting of creosote and carbolineum Avenarius heated to a temperature of 82 deg. Cent. (180 deg. Fahr.) and applied in two coats with a brush; (2) a bath composed of a 15 per cent solution of common salt and a 6 per cent solution of zinc-chloride and creosote, the wood being immersed or steeped in an open tank in successive hot and cold baths of this agent; (3) treatment in a closed retort in a vacuum and under pressure, the agent used being zinc-chloride solution and creosote. In a modification of Blythe's system the wood is submitted in a retort to the action of superheated steam at a minimum temperature of 200 deg. Cent. (392 deg. Fahr.), which steam is caused to pass over a reservoir containing creosote, the products of condensation, comprising water and creosote, being then drawn off, the retort filled with a charge of creosote, and steam pressure applied, the creosote being extracted from the water evacuated during the first stage for further use.

A system used in France many years ago, and said to have given excellent results, consists in placing the wood in a tank with a layer of quicklime on the top, which lime is slowly slaked with water, the time required for this treatment being about seven days. The timber so treated is said to acquire a remarkable degree of hardness. A process used in Belgium consists first in exposing the wood in a retort to a vacuum and afterwards impregnating under pressure with an agent formed by a ⅔-solution of gutta-percha to ⅓ of paraffin and heated until sufficiently liquid. An infusion of quassia wood has been used with some success. A strong solution of sulphate of iron and sulphate of copper, injected under pressure (Boucherie and Sage and Fleury-Pironnett processes). A steaming-vacuum-pressure process, sulphate of copper (Sage and Fleury-Pironnett), this process should be carried out within about ten days of felling the timber, and the life of wood so preserved is affected by the nature of the soil it may come in contact with. Tungstate of soda and water solution of a specific gravity of 1.2 (Jones's process). Sulphur immersed in nitric acid and distilled (Evelyn's process). Hot anthracene oil used at Dortmund collieries. To every gallon of water 3 ounces croton tiglium seeds, 3 ounces margosa bark, 3 ounces sulphur, 2 ounces blue vitriol, solution for preventing attack by white ants. "Sotor," preparation for protecting wood exposed to the action of sea water from attacks of the teredo navalis, and preventing decay (Peters). "Stoprot," a preventative of decay and dry rot, claimed also to be proof against insects and suitable for use in tropical climates, solution applied hot (Flichers). "Sideroleum" consists of a blend of hydrocarbon oils, claimed to possess great penetrative powers, and to carry the carbon into the pores of the wood without pressure, rendering sappy wood hard and rot proof. Applied cold by brush, and imparts a brown finish to wood (Anderson). Pfister's method of diffusion in freshly-hewn wood. Impregnation with molten sulphur. Falck's method of destroying the fungi or dry rot in buildings effected by heating beyond 40 deg. Cent. (104 deg. Fahr.), which is the temperature at which the mycelium of the merulius is killed. Owing to the fact that wood is a poor conductor of heat, it is considered desirable to raise the temperature of the entire building to 42 deg. Cent. (107 deg. Fahr.), and to maintain this temperature for at least 2 hours. It is important to be quite certain as to the exact nature of the growth, as if the fungi be grown inside the wood heat will only expedite the work of destruction, as fungi of this class flourish more actively at the temperature fatal to the dry-rot fungus. A combined seasoning and preservative process used in France consists of a tank charged with

ABSORPTION LIMIT OF HARDWOODS.
(From various authorities.)

		Pounds per cubic foot.
Blue Gum (Eucalyptus Globulus)	Australia	¾
Ironwood (Bumelia lycinides)	Eastern United States	1
Jaman	India	¾
Locust (Robina pseudacaica)	United States	⅜
Mahogany (Sureteina mahogoni)	Central America, Cuba	⅜
Oak (Quercus robur, etc.)	Europe, etc.	4–6
Teak (Oldfieldia Africana)	West Africa	1¾
Teak (Tectona grandis)	India	1¾
Sâl or Saul (Shorea robusta)	India	1
Sisso (Dalbergia Sisso)	India	3¼
Sundri	India	2¼
Swan River Wood	Australia	1¾

a solution composed of 5 per cent resin, 10 per cent borax, a trace of carbonate of soda. The wood is stacked on a lead plate in the bottom of the tank, and another lead plate is placed on the top, the former being connected with the positive pole, and the latter with the negative pole, of a dynamo. The current passes from the upper plate through the wood, by which it is said the sap of the wood is driven out, and the resin and borax takes its place, filling up the cells and interstices.

AMOUNT OF PRESERVATIVE ABSORBED BY VARIOUS WOODS.

In India the amount of absorption by hard woods, such as terminalia, tomentosa, and mesua ferrea, is stated to be 3 pounds per cubic foot; moderately hard woods, such as diptero-carpus tuberculatus, etc., 6 pounds per cubic foot; and soft woods such as pinus excelsa, pinus longifolia, etc., 10 pounds per cubic foot.

In France the woods most commonly used for sleepers are oak, beech, or pine, but fir, larch, and chestnut are occasionally employed. The French practice is to impregnate oak sleepers of about 3 cubic feet with from 8.8 to 12.3 pints of creosote; beech or pine sleepers, with about 44 pints of creosote each, the question of expense, however, frequently rendering it desirable to do with a less amount. According to the writer of an article which appeared in 1895 in the *Revue Générale des Chemins de Fer*, the weights of creosote injected per sleeper by the principal French lines for different kinds of wood, are as follows:

Description of Wood.	Railway.	Pounds.
Oak	All	11 to 15.5 (absorp. limit)
Beech	Northern	28.5
Beech	Western	33 to 35.25
Beech	Paris-Lyons-Mediterranean	35.25
Beech	Eastern	53
Pine	Midi	26.5 (absorption limit)
Pine	Orleans	31 "
Pine	Paris-Lyons-Mediterranean	26.5 "

Present practice tends to the injection of an increased amount of oil per sleeper. A report, presented at the International Railway Congress in 1895 by Mr. Herzenstein, states that the practice on the various lines in this country was to inject from 7 to 10 pounds of oil per cubic foot, with an average life of 16 to 20 years, an injection of from 7 to 8 pounds per cubic foot giving an average life of from 12 to 15 years. The amount inserted, according to later practice, is from 30 pounds to 35 pounds per sleeper. In France 18.4 pounds of oil per sleeper is used as a minimum.

On Indian railways the amounts of oil injected into sleepers of various woods are as follows: Beech and pine, 10 pounds of creosote oil per cubic foot; harder woods, such as oak, 3 pounds per cubic foot; piles of coniferous woods, 20 pounds per cubic foot. When chloride of mercury is used as an antiseptic, the amounts used per cubic foot are for hard wood, 3 pounds, moderately hard, 6 pounds, and soft, 10 pounds.

Mr. J. R. Baterden states (*Proceedings* Inst. C. E., 1904) that he has experienced no difficulty in getting into pitch-pine 7 pounds of creosote oil per cubic foot.

In the United States the usual amounts of creosote oil specified to be injected are as follows: For railway ties or sleepers, from 10 to 12 pounds per cubic foot; for dimension timbers, from 15 to 20 pounds per cubic foot; for piles, from 20 pounds to 30 pounds or more per cubic foot. Other experts advise the injection into the wood, in the full cell creosote process, of from 6 pounds to 12 pounds of creosote oil per cubic foot in the case of railway ties or sleepers, and from 10 pounds to 20 pounds per cubic foot in the case of timber and piling.

In the Rueping and Lowry processes the wood is first impregnated with from 10 pounds to 12 pounds of creosote oil per cubic foot, the amount left in the wood fibers on leaving the retort being from 2 pounds to 6 pounds per cubic foot.

Mr. J. B. Card, writing to the *Engineering News* (New York) in October, 1908, remarks that the treatment of sleepers with small doses of creosote oil has not been a success either in the United States or in Europe.

In Germany the usual amount of oil used for the impregnation of sleepers is 12 pounds per cubic foot.

Messrs. Richard Wade, Sons & Co., Ltd., who use the Rueping process on an extensive scale for treating telegraph poles, give the following results of a test with the latter as to amount of creosote oil absorbed and subsequent loss through draining out or leaching:

No.	L.	Diameter, middle.	Cubical contents. Caliper measure.	Weight before creosoting October 13th, 1910.	Weight after creosoting October 13th, 1910.	Absorption of creosote per cubic foot.	Subsequent Weighings. Nov. 1st, 1910.	Jan. 21st, 1911.	May 11th, 1911.	July 10th, 1911.	Loss of creosote per cubic foot.
		Ins.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	24	6½	5.51	258	318	10.85	312	290	280	278	7.21
2	24	7¼	6.88	292	402	15.98	397	379	356	241	8.87
3	24	7¼	6.88	248	344	13.98	340	318	302	293	7.41
4	24	7¼	6.88	268	398	18.89	391	371	360	334	9.30

LIFE OF PRESERVED WOOD.

Mr. V. Herzenstein, in the *Bulletin* of the International Railway Congress (July, 1910), from information collected from a number of railway companies, gives the average life of creosoted sleepers to be as follows:

Description of Sleeper	Main Line. Years.	Sidings. Years.	Total Years.
Creosoted Pine	15	5	20
Creosoted Oak	18	7	25
Creosoted Beech	20	10	30

Mr. Hausser, of the Midi Railway Company, France, in his report to the Seventh Session of the Railway Congress, says: "Although it is very difficult to lay down a rule that would be at all generally applicable, it may, however, be said that there is a unanimous opinion that pickling or preserving materially lengthens the life of sleepers, approximately doubling it in the case of oak, tripling it in the case of pine, and quintupling it in the case of beech."

A record of the removals of ties or sleepers on the New Mexico and Colorado divisions of the Atchison, Topeka and Santa Fé Railway, carefully kept from 1887 to 1907, shows the average life of these sleepers, which were treated on the zinc-tannin or Wellhouse process, to be 13.11 years. The number of ties or sleepers treated in 1885 was 111,503. At the end of 1907 the records showed that 77,000 had been removed 21 years after laying down, thus leaving 34,503 as having been removed during the years when no record was kept. It is to be observed that no care was taken in selecting the above 111,503 sleepers, and that many thousands of them are said to have progressed so far toward decay that but little prolongation of life could be secured from the preservative treatment. Had all the sleepers been carefully selected the average life would undoubtedly have been found to be considerably longer. The records of the Southern Pacific Railway show a mean life of from 8 to 9 years for burnettized ties or sleepers.

The *Engineering News* (New York) states that results obtained in the United States show that, by the zinc-chloride or burnettizing treatment, the life of the soft woods is more than doubled, meaning a life of from 8 to 12 for pine that usually lasts from 2 to 5 years. This is the mean life, the actual life being from 5 to over 20 years for treated pine ties or sleepers, against from 2 to 7 for the untreated ones. Creosoting gives from 25 to 50 per cent more life than the zinc-chloride process, but the cost of the former is three or four times that of the latter, and moreover, in the case of several woods creosote oil can only be made to effect a superficial penetration. The injection of from 10 to 15 pounds of creosote oil per cubic foot of wood, according to Mr. Card, gives a life of from 12 to 20 years.

LIFE OF UNTREATED AND TREATED SLEEPERS FROM DATA GIVEN AT THE LEWIS AND CLARK EXHIBITION, PORTLAND, ORE., 1905.

Species of Sleeper	Process	Life Untreated.	Life Treated.
		Years	Years
Texas Long-Leaf Pine	Rueping	4 to 6	15 to 20
Texas Short-Leaf Pine	Rueping	3 to 5	10 to 15
Texas Loblolly Pine	Rueping	2 to 5	10 to 15
Washington Red Fir	ZnCl.	5 to 6	10 to 12
Mont. Lodgepole Pine	ZnCl.	4 to 5	10 to 12
Black Hills West-Yellow	ZnCl.	5 to 6	10 to 12
Michigan Hemlock	Wellhouse	5	10
Michigan Tamarack	Wellhouse	5	10 to 15
Beech	Creosote	4 to 5	20 to 30
Red Oak	Creosote	4 to 5	20 to 30

Mr. Batterden (*Proceedings* Inst. C. E., 1904) states that about 7 pounds of creosote oil per cubic foot injected into piles at a temperature of 40 deg. Cent. (120 deg. Fahr.), and pressure of 150 pounds per square inch, gave protection against the marine worm for 18 years.

Mr. De Kermond (*L'Electricien*, Paris) states that official tests have shown that posts treated with copper sulphate have a life of 13 years 9 months; by the Kyan or mercuric-chloride process, nearly 17 years; and by the creosoting process, 19 years 8 months.

COST OF PRESERVATIVE TREATMENT.

The cost of pickling or treating wood varies considerably, according to the wood being treated, the process employed, and the country, or even the district, where the work is being carried out, etc.

The cost of creosoting in England on the pressure system varies from 3d. to 5d. per cubic foot, in accordance with the price of the oil and the amount injected. For estate work the amount of oil used for impregnation is generally about 0.75 gallon per cubic foot, and the labor of attending to the working of such a creosoting plant is calculated at 0.5d. per cubic foot. At the present time the price of creosote oil is 4d. per gallon, so that the price works out at 3.5d. per cubic foot. Creosoting timber for railway purposes costs for pine and fir from 2.9d. to 5.1d. per cubic foot.

In India the cost of impregnating railway sleepers is given as 1s. for 3 pounds, 2s. for 6 pounds, and 3s. for 10 pounds, impregnation per cubic foot, with creosote oil at 7 annas (10½d.) per gallon.

In France creosoting on the Paris-Lyons-Mediterranean Railway is given by Mr. Herzenstein (*Bulletin* of the International Railway Congress, 1901) as for oak 1.6d. per cubic foot, for fir 5.4d. per cubic foot. On the Northern Railway, with the Blythe creosoting process, 1.8d. per cubic foot for oak, and 3.5d. per cubic foot for fir. A writer in the *Revue Générale des Chemins de Fer* gives the average cost of creosoting on French railways as being, for oak 8.6d., and for beech or pine from 1s. 3.5d. to 1s. 9.3d. per sleeper, according to the amount of oil injected.

		Per Sleeper
1	Burnettizing or zinc-chloride process (about ½ pound of dry zinc per cubic foot)	$0.12 (6d.)
2	Wellhouse or zinc-tannin process (½ pound of dry zinc plus glue and tannin per cubic foot)	.16 (8d.)
3	Card, Rutger or zinc-creosote process (1½ pounds of creosote oil and 1 pound of dry zinc per cubic foot)	.18 (9d.)
4	Rueping, partial cell process (about 6 pounds of creosote oil per cubic foot)	.225 (11d.)
5	Lowry, partial cell process (6 pounds of creosote oil per cubic foot)	.225 (11d.)
6	Absorption or open-tank process (about 6 pounds of creosote oil per cubic foot)	.230 (11.5d.)
7	Full cell creosote process (about 10 pounds of creosote oil per cubic foot)	.335 (16.5d.)

In the United States, from information compiled by Mr. J. D. Isaacs, Permanent Way Engineer to the Southern Pacific Railway, it appears that at Oakland, Cal., and Latham, Ore., the amount of creosote oil injected is from 1.12 gallons to 1.18 gallons per cubic foot, or an average of about 10 pounds per cubic foot, and the average cost (including price of oil, fuel, labor, maintenance, oil waste, and water) is 15.96 cents, or about 8d. per cubic foot. The average tie or sleeper used in the United States contains approximately 3.5 feet.

The cost of treating best woods for paving-blocks with 16 pounds of oil per cubic foot is 16 cents (8d.) per cubic foot. On the authority of Mr. Rowe, for the full creosote process, with an injection of 15 pounds of oil per cubic foot, a 3 cubic foot tie or sleeper would cost 38.29 cents (19.18d.), and a 3.75 cubic foot tie or sleeper 47.95 cents (23.97d.). This works out at 12.78 cents (6.39d.) per cubic foot, and 12.52 cents (6.26d.) per cubic foot.

The Allis-Chalmers Company, Milwaukee, Wis., give the following as the approximate cost of treating sleepers, exclusive of royalties, by the seven most-used preservative processes, the average size of hewn tie or sleeper being 7 inches × 9 inches × 8 feet = 3.45 cubic feet:

COST OF TREATING SLEEPERS FROM DATA GIVEN AT THE LEWIS AND CLARK EXHIBITION, PORTLAND, ORE., 1905.

Species of Tie.	Process.	Amount of Preservative.	Cost of Treatment.
Texas Long-Leaf Pine	Rueping	16 pounds creosote per sleeper	16 cents. (8d.)
Texas Short-Leaf Pine	Rueping	16 pounds creosote per sleeper	16 cents. (8d.)
Texas Loblolly Pine	Rueping	16 pounds creosote per sleeper	16 cents. (8d.)
Washington Red Fir	ZnCl	½ pound creosote per cubic foot	10 cents. (5d.)
Mont. Lodgepole Pine	ZnCl	½ pound creosote per cubic foot	10 cents. (5d.)
Black Hills West Yellow	ZnCl	½ pound creosote per cubic foot	10 cents. (5d.)
Michigan Hemlock	Wellhouse	½ pound creosote per cubic foot	12 cents. (6d.)
Michigan Tamarack	Wellhouse	½ pound creosote per cubic foot	12 cents. (6d.)
Beech	Creosoted	56 pounds creosote per sleeper	60 cents. (2s. 6d.)
Red Oak	Creosoted	25 pounds creosote per sleeper	30 cents. (1s. 3d.)

Approximate cost of treating wood paving-blocks, the usual dimensions being 3.5 inches to 4 inches deep and cut from timber 3 inches × 6 inches, 3 inches × 8 inches, 3 inches × 10 inches, 4 inches × 6 inches, or 4 inches × 10 inches. Seasoned blocks, weighing about 20 pounds per cubic foot. Cost based on creosote oil at about $0.07 per gallon, and balance of treatment $0.02 per cubic foot.

Depth of Block		3½ inches	4 inches
Pounds of creosote	To each square yard	2.63 cubic feet	3.00 cubic feet
per cubic foot	of blocks	42.08 pounds	48.00 pounds
16	Creosote	42.08 pounds	48.00 pounds
	Weight after treatment	147.28 pounds	168.00 pounds
	Approximate cost of treating	$0.39	$0.45
18	Creosote	47.34 pounds	54 pounds
	Weight after treatment	152.43 pounds	194.00 pounds
	Approximate cost of treating	$0.44	$0.50
20	Creosote	52.60 pounds	60.00 pounds
	Weight after treatment	157.80 pounds	200.00 pounds
	Approximate cost of treating	$0.48	$0.54

The cost of treating piles is said to be $0.10 per cubic foot, with 10 pounds of oil per cubic foot, each additional pound of oil costing an additional cent. Piles range from 8 inches to 20 inches in diameter, and from 10 feet to 90 feet in length, the average sizes running about as follows: 10 inches to 14 inches diameter, by 28 feet in length; 11 inches to 15 inches diameter, by 40 feet in length; 8 inches to 18 inches diameter, by 60 feet in length; 8 inches to 20 inches diameter, by 90 feet in length. Green piles weigh about 55 pounds per cubic foot, and seasoned or steamed piles, about 30 pounds per cubic foot. The average treatment of piles in the United States is from 10 pounds to 20 pounds of creosote oil per cubic foot.

The cost of creosoting timber with 10 pounds of creosote oil per cubic foot is about $8 per thousand board feet, and for each additional pound of creosote oil used $0.75 must be added, creosote oil being taken at $0.07 per gallon.

The cost of the chloride of zinc or burnettizing process for timber, with ½ pound of dry zinc chloride per cubic foot, is about $3 per 1,000 board feet. Treatment with "burnettizing" costs about the same as creosoting, viz., 5d. per cubic foot.

The price of corrosive sublimate used in the kyanizing process has, combined with the slowness of the process, caused it to fall into disuse in England, and, at the present time, probably the United States is about the only place where it is still used to some extent in certain localities where there is a difficulty in obtaining chloride of zinc and oil of creosote. In England the price of corrosive sublimate is such as to render its use as a preservative agent impossible, with creosote oil in the neighborhood of 4d. per gallon, and pure zinc-chloride at 2d. per pound.

The cost of treating sleepers on the chloride of zinc process has been found by the Southern Pacific Railway Company to average, with two of its portable plants, 8.20 cents (4.1d.) and 7.41 cents (3.7d.) per tie or sleeper, or 2.5 cents (1.25d.) per cubic foot.

The zinc-tannin, or Wellhouse process, is considerably more expensive, the actual cost at four of the standard works in the United States is given by Mr. Rowe as being, for a 3 cubic feet sleeper, 7.81 cents (3.9d.) for chemicals, and 4.61 cents (2.3d.) for labor, or a total of 12.42 cents (6.21d.) per sleeper. According to this the cost per cubic foot is slightly over 4 cents (2d.).

The Rueping partial cell process, with an impregnation of 5 pounds of creosote oil per cubic foot, and taking the oil at 4d. per gallon, costs about 2.75d. per cubic foot.

The cost of the zinc-creosote process (Rutger and Card) would be about 3.25d. per cubic foot, the higher cost being due to the zinc-chloride required per cubic foot in addition to the creosote oil.

The cost of preserving by the Crésol-calcium process is stated to be as follows: In England, 0.47d.; in Sweden, 0.5d.; and in India, 0.6d. per cubic foot.

The cost of the saccharine or powellizing process is given as being in Bombay 5 annas (7.5d.) per cubic foot, and in Western Australia 3.08d. per cubic foot, plus the royalty to the patentees. Where sugar is very cheap, the cost, exclusive of royalties, would, according to Mr. Ryan, be 1.35d. per cubic foot.

The following is the approximate average cost of impregnation with 15 different antiseptics, including processing, from various sources:

	Process.	Cost per cubic foot
1	Atlas (10 per cent solution)	3d.
2	Bélit	1.75d.
3	Carbolineum	1.5 to 3.8d.
4	Chloride of zinc	.72 to .91d.
5	Chloride of mercury	8d.
6	Crésol-calcium	.46 to .6d.
7	Crésoyle	3d.
8	Green oil	1.9 to 4d.
9	Jodelite	4.9 to 7d.
10	Microsol	3 to 4d.
11	Rueping	1.2d.
12	Saccharine solution	1.36 to 7.5d.
13	Solignum	1.2d.
14	Sulphate of copper	5.2d.
15	Vulcanizing	2.5 to 4d.

CONCLUSION.

Fundamental Points to be Considered in Plans of Wood-preserving Works. The following points are given by Mr. Rowe as the result of extensive experience in the United States: (1) That the works should be proportioned throughout to secure the desired output. (2) That each part should be proportioned to do the desired work, and at the same time so proportional to all the other parts that there will be no useless or surplus capacity or useless cost. (3) That each part perform its functions in the most direct and in the simplest manner. (4) That every part be of the best manufacture, and the most reliable for lasting service, so that repairs will be infrequent, saving loss of time and expensive maintenance. (5) That the working parts be so arranged as to be promptly operated with the least manual labor. (6) That the plans of all the essential parts be fully designed and prepared so that there be no extra labor or delay during erection. (7) That the arrangement of the works be such that accurate measurements and weights shall be provided for, so that it shall be possible to know what is being done at any one time. (8) That the operator of the works shall be thoroughly competent, experienced, thoroughly honest, and faithful, so as to be a safeguard between the two parties concerned.

The approximate weights in tons of machinery, etc., with two retorts for working the five most-used processes are as follows: Zinc-chloride or burnettizing, 316; zinc-tannin or Wellhouse, 331; zinc-creosote or Rutgers, 331; Rueping, 351; creosoting, 316.

The following practice has grown up at Mr. Octave Chanute's works: (1) To refuse to treat fresh-cut timber, but to put all such timber down to season. (2) To begin the spring season's treating by steaming unless the timber is of the previous year's cutting. (3) To omit steaming in summer and autumn when the timber proves to be well seasoned.

Vesuvius as a Fertiliser. A Swiss scientist, Dr. Kleiber, has discovered that the ashes which still largely cover Herculaneum and Pompeii contain large quantities of potash and clay, from which an excellent agricultural fertilizer can be obtained. The whole region is very rich in potash, and it is said the Italian government is seriously intending to organize the exploitation of "Vesuvian Mines."—*Les Annales.*

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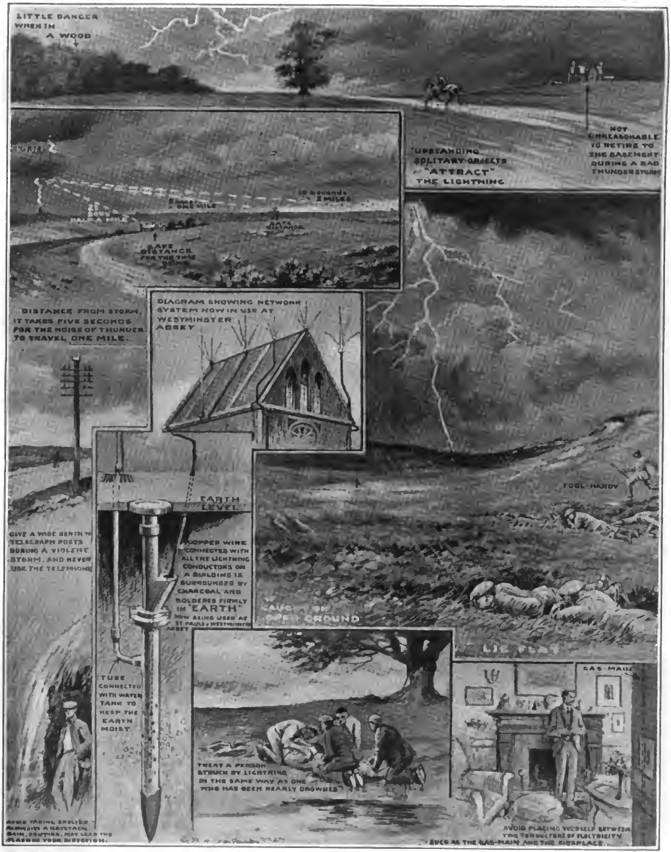

LITTLE DANGER WHEN IN A WOOD
"UPSTANDING SOLITARY OBJECTS "ATTRACT" THE LIGHTNING
NOT UNREASONABLE TO RETIRE TO THE BASEMENT DURING A BAD THUNDERSTORM
STORM
10 seconds 2 MILES
5 seconds ONE MILE
SAFE DISTANCE
SAFE DISTANCE FOR THE TIME BEING
DISTANCE FROM STORM. IT TAKES FIVE SECONDS FOR THE NOISE OF THUNDER TO TRAVEL ONE MILE.
DIAGRAM SHOWING NETWORK SYSTEM NOW IN USE AT WESTMINSTER ABBEY
EARTH LEVEL
GIVE A WIDE BERTH TO TELEGRAPH POSTS DURING A VIOLENT STORM, AND NEVER USE THE TELEPHONE
COPPER WIRE CONNECTED WITH ALL THE LIGHTNING CONDUCTORS ON A BUILDING IS SURROUNDED BY CHARCOAL AND SOLDERED FIRMLY IN "EARTH"
NOW BEING USED AT ST PAUL'S, WESTMINSTER ABBEY
FOOL-HARDY
CAUGHT IN OPEN GROUND
TUBE CONNECTED WITH WATER TANK TO KEEP THE EARTH MOIST.
TREAT A PERSON STRUCK BY LIGHTNING IN THE SAME WAY AS ONE WHO HAS BEEN NEARLY DROWNED
GAS-MAIN
AVOID TAKING SHELTER ALONGSIDE A HAYSTACK. RAIN, DRIPPING, MAY LEAD THE FLASH IN YOUR DIRECTION.
AVOID PLACING YOURSELF BETWEEN TWO CONDUCTORS OF ELECTRICITY SUCH AS THE GAS-MAIN AND THE FIREPLACE.

From the *Illustrated London News.*

How to get struck by lightning, and how not to.

LIGHTNING AND ITS DANGERS.—[See page 102.]

Thermo-Electric Measurements of Stellar Radiation*

By the Aid of a New Type of Thermo-Electric Junction

By A. H. Pfund

IN the year 1901 Prof. E. F. Nichols published an account of his radiometric determinations of the "Heat of the Stars."[1] He was, in fact, the first to show that such extremely minute quantities of radiant energy could not only be detected but could be measured to a very fair degree of accuracy. In spite of the encouraging prospects which this work held forth, nothing further was done for more than a decade. Within the past year or two the writer has had occasion to develop a sensitive thermo-electric junction which gave promise of yielding useful results when applied to the measurement of stellar radiation. As the opportunity presented itself of using the 30-inch Keeler Memorial Reflector at the Allegheny Observatory, the apparatus was carried to Pittsburgh and tried out. The work was merely of a preliminary character and its object was, mainly, to learn of the difficulties which would have to be overcome in order that useful results might be obtained. In spite of the imperfections of the apparatus and the unavoidably great distance (more than 40 feet) between the thermal junction and the galvanometer, very reliable deflections considerably larger than those of Nichols were obtained. The apparatus had to be so designed that the thermal junction could be slipped into the eye-piece end of the telescope, from which wires could be led to the galvanometer mounted in another part of the building. The actual arrangement used is shown in Fig. 1, where *A* is the brass tube which slips into the telescope; *B* is the capsule containing the thermal junctions which are mounted at *C*. The front and rear openings of the capsule are closed by plates of fluorite (*F*) and glass (*G*), respectively. The eye-piece (*E*) enables the observer to see the junctions and the star image. The charcoal evacuator (*H*) and the binding-posts (*P*) are attached as indicated.

Two types of thermal junctions were made, but unfortunately the one of inferior design had to be used, as the other was of too high a resistance to yield the desired sensibility. The type used is shown in Fig. 2, where *A* and *B* are the blackened disks upon either of which the star image could be projected. The filaments 1 and 2' were of a bismuth and tin alloy, and those marked 1' and 2 were of a bismuth and antimony alloy. As is obvious from the figure, the filaments 1, 2, 1 and 1', 2', 1' form two separate compensating junctions of which the blackened disks *A* and *B* form the receiving surfaces. Each disk is composed of two parts which overlap slightly but do not make electrical contact. A compensating system is necessary in order that any stray radiation from a warm mass of water vapor or carbon dioxide might fall upon both junctions and thus produce no resultant galvanometer deflection; while the radiation from the star, falling on but one junction, would alone be responsible for the effects observed. The area of each disk was 1.1 square millimeters, and the separation of their centers was 4 millimeters. As this separation was unnecessarily large, a second type of junction, shown in Fig. 3, was constructed. Here the disks were separated by a clear space of 0.5 millimeter. As better compensation is to be obtained by the use of this type of junction, it is to be recommended for future work. The actual method of making these delicate junctions has been described elsewhere.[2]

The evacuator (*H*), Fig. 1, is simply a highly exhausted vacuum tube containing cocoanut charcoal as one electrode. Whenever it becomes necessary to remove the small amount of gas which has leaked into the capsule containing the thermal junctions, it is only necessary to establish an electrical discharge by means of a small transformer suitably connected to the terminals of the tube. This process produces so high a vacuum that the sensibility of the thermal junction increases at least five times over that which it had when surrounded by air at atmospheric pressure, and in addition to its portability, it has the further advantage over Dewar's process that the charcoal retains the gases once absorbed.

The D'Arsonval galvanometer used was designed by Dr. F. Wenner and was made in the instrument shops of the Bureau of Standards. On open circuit the complete period of the suspended system was 11 seconds. Under actual working conditions the voltage-sensibility with the scale at 5 meters was about 6×10^{-9} volts. Although the mirror, which was 6 millimeters in diameter, ought to have shown sufficient resolving power to give a sharp image at this scale distance, it was found that imperfections of figure in the mirror made it impossible to read deflections closer than fifths of a millimeter. The galvanometer was mounted on a stone pier built up from the ground and free from contact with the floor, thus giving great stability to the instrument.

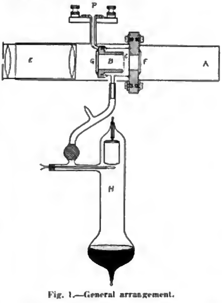

Fig. 1.—General arrangement.

A test of the sensibility of the apparatus was carried out by exposing one of the junctions of the thermal couple to a standard Hefner lamp at a distance of 5 meters. The resultant deflection was 96 millimeters which corresponds to a deflection of 2,400 millimeters with the Hefner lamp at 1 meter. The 30-inch telescope is of the Cassegrain type, and, as a consequence, a central disk 8 inches in diameter is rendered inoperative by the secondary mirror. Taking this into consideration and neglecting atmospheric absorption, it appears that, if the image of the Hefner flame were focused on the disk of the thermal couple by means of this telescope, a deflection of 1 millimeter would result if the lamp were removed to a distance of about 8 miles.

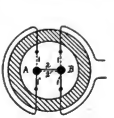

Fig. 2.—The thermal junction.

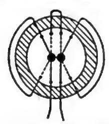

Fig. 3.—Thermal junction with closed disks.

The method of measuring the total radiation of a star was briefly as follows: The thermal junction mounting was rotated axially until the line connecting the two blackened disks lay in the direction of the telescope's motion in declination, thus enabling the observer at the telescope to shift the star image from one disk to the other simply by turning a handle that slightly changed the pointing in declination. This act of shifting the star image required from 1 to 1.5 seconds. To begin with, the star image was kept on one disk and when the observer at the galvanometer was ready, he whistled once, whereupon the observer at the telescope also whistled once and immediately shifted the star image to the other disk. Twenty seconds after returning the first signal the observer at the telescope whistled twice in rapid succession, and the observer at the galvanometer recorded the deflection. The next deflection was obtained in a similar manner by shifting the star image in the opposite direction. This prolongation from 5.5 seconds, the half period of the galvanometer on open circuit, to 20 seconds, was due largely to electromagnetic damping occasioned by short-circuiting the galvanometer through the thermal couple, which had a comparatively low resistance. As the galvanometer was not specially constructed for this work, the above conditions were unavoidable. In spite of this rather long time of exposure, the deflections were so constant that, no doubt, a considerably longer exposure might have been possible without sacrificing accuracy of result.

On the evening of September 22nd, 1913, the final series of results were obtained. This was the only evening between the time that the apparatus was ready and the time set for the writer's departure for Baltimore, that the sky was sufficiently clear for observations, and on that evening conditions were favorable only until about 11 P. M. During this series of observations, Dr. Grondahl carried out the manipulations at the telescope while Mr. Zaccheus Daniel and the writer observed the galvanometer deflections. After ten or more deflections had been noted, Dr. Grondahl and the writer exchanged places, Mr. Daniel continuing in observing the deflections. The results obtained are here given:

Source.	Deflection. Millimeters.	Visual Magnitude.	Remarks.
Vega	7.5	0.19	Clear sky, no wind.
Jupiter.	3.0	—2.0	Clear sky, no wind
Altair	2.0	0.96	Hazy sky, no wind.

In every case the flections followed so definitely when the signal was given that not even a skeptic could have doubted the reality of the effect. The galvanometer zero was remarkably steady, and in every case was it possible to predict the direction and approximate magnitude of the deflection, after having observed the first of a given series. The deflections were so consistent that among the ten or more readings taken on Vega, the difference between the largest and smallest was less than 1 millimeter. Considering the crudity of the signaling and timing devices, such differences in reading are not surprising. In the case of Jupiter it was found impossible to receive the entire image of the planet on the blackened disk of the thermal junction. The equivalent focal length of the reflector as used was about 60 feet; as a result, the image of Jupiter was 3.4 millimeters in diameter and 8.4 square millimeters in area. Since the blackened disk had an area of 1.1 square millimeters, less than one seventh of the total radiation was received. If the entire image of Jupiter could have been concentrated on the thermal junction a deflection of 23 millimeters would have been obtained. It goes without saying that the disk of the thermal junction was amply large to receive wholly the images of Vega and Altair.

In order to test whether the necessary slight motion of the telescope in declination might affect the observed deflection, the star was thrown out of the field, and the telescope was given the former slight motion several times at the usual signals. No resultant effect was observed.

A comparison of the preceding results with those of Nichols is not easy. Nichols's radiometer was carefully shielded from draughts and was mounted in a room into which the star image was projected. In the present work no protection was given the thermal junctions, lead wires or galvanometer. Furthermore, the thermal junctions were mounted in the open dome of the observatory where air draughts were unavoidable and where the temperature was several degrees lower than in the room containing the galvanometer. That reliable results were obtained even under these conditions is due to the excellence of compensation throughout the system. In the comparison of results such differences as areas of receiving surface, size of reflector, nature of standard comparison source, etc., increase the complication. A rough calculation shows that if Nichols had used the 30-inch reflector with his best radiometer (used in 1900) and had also carried out "double deflections," he would have obtained from Vega a deflection of 2.26 millimeters, whereas the writer obtained 7.5 millimeters. Under the actual conditions of his experiments which involved the use of a 24-inch reflector, Nichols obtained a deflection of 0.51 millimeter from Vega.

As to the desirability of developing such apparatus as this but little need be said, for it is evident that, by means of a radiometric device, entirely new problems in Astrophysics may be attacked. As for the thermal junction, its development for such work has only begun. That thermal junctions of still higher sensitiveness may be made is more than probable; and it is certain that, thanks to the labors of Abbott and Paschen, Thomson galvanometers, easily ten times as sensitive as the D'Arsonval used by the writer, may be constructed and used with success. Such improved apparatus, used in conjunction with one of the largest reflectors, would make possible the study of stars of even the fourth magnitude.

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* From the Publications of the Allegheny Observatory of the University of Pittsburgh.

[1] *Astrophysical Journal*, 13, 101, 1901.

[2] *Physikalische Zeitschrift*, 13, 870, 1912.

Battleships and Submarine Attack

In view of the widespread war in Europe, that will undoubtedly involve most of the great navies of the world, a paper recently read by Sir John Biles before the Institute of Naval Architects at Newcastle-on-Tyne on "Battleships and Submarine Attack" has proven most pertinent and opportune; and this paper, together with a letter written to the *Times* by Sir Percy Scott on the submarine menace, is made the subject of an editorial discussion in the *Engineer*, London, from which the following extracts are taken:

"Sir John Biles's paper briefly raised four main points, which, slightly transposed, were: whether the submarine menace was sufficient to justify armoring the under-water portions of a ship to a much greater extent than is done at present, and, if so, whether 4-inch armor would form sufficient protection; or was the menace sufficient to justify the construction of smaller and slower battleships carrying six guns only instead of eight or ten, and would armor be of sufficient value to justify a modification in the form of ship, which, although facilitating the manufacture of the armor, would offer greater resistance than the ordinary form? In the course of the subsequent discussion, answers to these queries were afforded by the statesman, the naval officer, and the ship constructor to a varying degree. The fourth question was immediately shattered by Mr. Charles Ellis, who expressed the opinion that just as armor plate makers had already been forced to provide shapes which were considered impossible only a few years ago, so they would be able to furnish in future armor of any shape likely to be required. Lord Brassey was disinclined to overlook the arguments in favor of the same total armament carried in more and smaller vessels, a view that Sir Philip Watts contradicted in his remarks. He alone categorically answered all the four questions propounded, and his views are of great interest, as he stated plainly that up to the present time the submarine menace had not been considered of sufficient importance to justify armor protection on the bottom of a ship; but he thought that 4-inch armor, if supported by suitable internal subdivision, would afford sufficient protection against torpedoes. Sir Reginald Custance confined himself to the war value of the Whitehead torpedo, and, basing nearly all his remarks on the experience of the Russo-Japanese war, regarded the torpedo as a very inferior weapon to the gun, and one on which too much reliance should not be placed. Prof. Hovgaard's contribution to the discussion dealt mainly with the constructional possibilities in protecting a vessel's bottom, and pointed out that to do so effectually against external explosions a resistance greater than that afforded by the inertia of the water must be provided. For a big charge and a depth of 20 feet this would seem almost impossible.

"It is also curious that this sudden phase of thought over the dangers to a vessel of a torpedo striking her should have led to so much discussion without anyone having pointed out that it is quite immaterial whether the torpedo is fired from a surface craft or a submarine, and that the danger from the former is also a very serious matter indeed with modern long-range torpedoes, and one in which, as far as destroyers are concerned, there is already a considerable amount of war experience. Certainly, hitherto the whole argument has had nothing to do with craft other than submarines, but at the back of the whole question lies the capability of the structure of the modern battleship to withstand torpedo attack. The matter has been debated every year since the introduction of the automobile torpedo nearly forty years ago. Put on 4-inch armor and increase the sub-division—Sir Philip Watts suggested even thicker armor if necessary—and what will be the result; only to increase the diameter, and with it the bursting charge, of the torpedo? What has been the history of the gun? Till Sir Percy Scott led the way in target practice it is doubtful if the percentage of hits with it in war time would have been any better than it was with the torpedo in the Russo-Japanese war. In fact, in the Spanish-American war it was vastly less. The experience in the Sea of Japan with 16-inch and 18-inch torpedoes was sufficient seriously to affect the internal protection and sub-division of the entire Dreadnought type, and this was before the introduction of the 21-inch torpedo with its hot air attachment and gyroscopic control; and what Scott did for the accuracy of the gun, these have accomplished for the torpedo. Many officers seem to think that the menace of destroyers is a vastly greater deterrent than that of submarines which are relatively slow, and there is no doubt that with the range and accuracy of its existing weapons the surface boat is a very formidable antagonist to the big ship. It is, however, a visible foe; but, on the other hand, it is a habitable one. These conditions are largely reversed in the case of the submarine, which by no means possesses the sea-keeping capabilities of the destroyer. Why, then, was the risk of a successful destroyer attack, i. e., if a torpedo got home, treated so lightly? Why has the destroyer programme been reduced in England and France and the submarine flotilla increased? The fact is that warship design is in a state of flux, and even among naval officers there is a very wide diversity of opinion as to the relative value of various types.

"The limitations to increase of size in torpedoes are less than in the case of artillery, and consequently a more dangerous projectile can be introduced with relatively small difficulty in order to maintain the superiority of the attack. To this the only real answer that can be made is a radical change of type of big ships, rather than the piling on of defensive properties. Effectively to armor the under-water sides of a vessel of the type of the 'King George V' would involve reducing the main waterline belt from 12 inches to 10 inches, and the upper portion of the side from 9 inches to 7 inches and 5 inches, while at the same time it would require an addition to the displacement of some 2,000 tons. That heavier plating will likely be adopted in future is quite another matter. Small thick plates are ill-adapted for withstanding gaseous pressures on account of the difficulty of adequately joining them; the necessity for providing against the intense local percussion caused by a projectile is absent in the case of the torpedo, where the effect is more widely distributed. Actual armor of the present type is, therefore, far less likely to be adopted than steel plates perhaps 1½ inch or 2 inches thick worked in such a fashion that the joints are as remote as possible from one another, and are reinforced on the inside to a much more elaborate extent than is at present provided for above-water work. But when this is done the 21-inch torpedo with its 330-pound charge will become the 24-inch type carrying 500 pounds, and the problem will again require solution. That Sir Percy Scott had this in view when he started to stir up discussion seems very certain; but no one pointed out this fact during the discussion on Prof. Biles's paper. Even with armor and sub-division below water, the attack must remain superior to the defence for the simple reason that all that is necessary is to fire two tubes instead of one. Just as in volley firing it is possible simultaneously to put several 12-inch shells into the space of a tennis court at long ranges, a submarine that can rely on hitting with one tube can almost certainly hit with two, and no defence will withstand such an impact. Naturally, this does not relieve naval architects of the onus of providing all the protection possible to the hull, though obviously the best defence is the destruction of the submarine. How that is to be accomplished is extremely difficult to see, because the type is tending more and more to merge into the sea-going destroyer with submersible capabilities, and of a size and speed that will render it not only much more habitable, but capable of undertaking work at present far beyond its power."

[Sir John Biles's paper in full, with illustrations, will appear in the next issue of the SUPPLEMENT.]

The Geological Action of Man*

By Paul Combes

EVERYTHING in the universe changes more or less rapidly, for change is the essence of phenomena. The surface of the earth has undergone continual alteration since its formation. Most of these changes are due to the physical agencies, which for a long period were the only ones in operation, but the advent of life upon the globe introduced another factor of ever-increasing importance in geological and topographical modifications.

Of all living things, man has produced the most marked effect upon his environment. In order to take account of man's action on the earth's surface, it is necessary to picture the earth as it would appear if the human race had never existed, and to compare that ideal image with the reality. Man acts, successively: as a hunter, upon animal life; as a herdsman, upon both animal and vegetable life; as a farmer, upon vegetable life chiefly; and as a miner and engineer, upon the mineral shell of the earth itself.

Tribes that live by hunting and fishing cause the extinction or diminution of certain animal species. The African elephant is rapidly disappearing. Soon his action upon the tropical flora will cease, and factories and telegraph lines will no longer be in danger from his assaults.

The right whale has taken refuge in Arctic waters and has influenced the distribution of human beings in those regions.

Pastoral peoples, by keeping herds of cattle, sheep, and goats in mountainous regions, destroy the herbage and cause the formation of torrents. The goats and sheep literally "clear" the land on which they browse, and permit the rains to wash away the soil until the rock is laid bare. These animals have ruined Palestine, Greece, and Sicily, transforming these once fertile lands into deserts of bare, sunburned rock.

Agriculture is the most potent factor of topographical changes. See what it has made of the vast marshy forest that was ancient Gaul. The deforestation, clearing, and desiccation of land effected by man since he became an agriculturist, have profoundly modified the distribution, and consequently the very important action, of water on the earth's surface. Intensive culture exhausts the soil by extracting its fertilizing elements, and the fertilizers which man applies in compensation alter the composition of the soil. By burying his dead within the narrow confines of cemeteries, man withdraws from circulation enormous quantities of phosphorus which are thus lost to vegetation. The most fertile lands are transformed into deserts by centuries of cultivation. In this way the rivers have gradually carried down to the sea the elements of fertility of Mesopotamia, Bactriana, and many other lands which once were celebrated for their richness, but now are arid and desolate.

As soon as human communities are formed they act directly upon the surface of the earth. In order to build cities and to establish easy communication between them, man was compelled to execute extensive earth works, to exploit quarries and mines. Still greater alterations of the earth's surface were subsequently produced by the construction of roads, canals, bridges, and aqueducts. The hydraulic engineer has effected equally important changes, straightening the courses of rivers, confining them by dikes, dredging harbors and protecting them by jetties. If the shores of oceans and rivers, thus determined by human action were designated by a special color on a map of the world, their extent would be found surprising.

Man is not content with draining and cultivating swamps and even the beds of lakes—Lake Fucino, in Italy, for example. He conquers vast domains from the sea, as the Dutch have done with their dikes, and as is still being done in the French bays of the Somme and Mont St. Michel. If we had properly studied and comprehended the inspired idea of Commandant Roudaire, we should have created a sea in Algeria and fertilized the Sahara. Man, who has made so many deserts, may perhaps be able to reclaim them. This is being attempted in Algeria by anchoring the sand dunes and sinking artesian wells.

The construction of railways has accelerated the change in the earth's surface, by making cuttings and embankments, filling ravines, spanning rivers, and tunneling through mountains. Here the potency of human action is especially marked. To appreciate this fully, one must have heard the detonations of dynamite and the grinding of drills, and seen the solid granite shattered in the bowels of the mountain.

As the mountain no longer stops the railway train, so the isthmus no longer stops the ship. Suez, Panama, Corinth, Kra, and many other isthmuses have ceased, or will cease, to be what geological agencies made them. Marine fauna migrate from ocean to ocean through the new artificial channels, and islands hitherto neglected become suddenly transformed in consequence of their proximity to the new routes of commerce.

Man will continue to alter the earth's surface in furtherance of his own interests until every line of the map of the world shall bear the impress of human activity. From his advent until his disappearance from the earth man has been and will be the most active, if not the most powerful, of geological agents. Yet his works and his very existence are at the mercy of terrestrial dynamics.

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* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Cosmos.

Iron Ore Output of the World

ACCORDING to an article by C. K. Leith published in the Engineering Supplement of the *London Times*, the annual output of iron ore in the chief producing countries during the latest period (average of 1909, 1910 and 1911) for which the figures are available, was: United States, 50 million tons; Germany, 27; United Kingdom, 15; France, 14; Spain, 8; and Sweden, 5 million tons. Continued heavy production may be expected of the Lake Superior ores, the ores of the Franco-German boundary, the Bilbao ores of Spain, the Cleveland ores of England, and the high-grade magnetites of North Sweden; while increasing quantities of ores may be expected from Sweden and Cuba, and the use of Clinton hematites and Adirondack magnetites in the United States will also probably increase. In the near future there will probably become available the Brazilian high-grade hæmatites, Chilean ores, and ore deposits of the western United States, western Canada, India and China.—*Journal of Franklin Institute.*

Development of the Westinghouse Turbine Reduction Gear

Providing a Method for Insuring Uniform Pressure Across the Entire Face of the Teeth of the Pinions

WHILE it was early recognized that the steam turbine was an extremely valuable type of motor for many purposes, it was also soon realized that when it was operated in the most economical manner its speed of rotation was far too great for satisfactory results in some of its most desirable applications. This was especially apparent in the case of marine propulsion, where the economical speed of the turbine is several times greater than that at which the screw propeller can be operated effectively.

Under these conditions it was evidently necessary to provide some form of reduction gearing, and among the gears of this class that have been successfully introduced is the Westinghouse gear, consisting of helical-toothed pinions upon the turbine shaft which operate large gears on the driven shaft, thus effecting the required reduction of speed.

The principal features of this gear are quite simple, but in working out the details of construction interesting problems arose, notably the "floating frame," which carries the driving pinion shaft, and insures uniform pressure across the entire face of the teeth of the pinions.

Not the least interesting feature in the development of this gear is the fact that the fluid pressure employed in the equalizing mechanism furnishes a constant index of the power being transmitted, thus constituting a constant indicating dynamometer.

In a gear to transmit large powers at high speeds it is essential that the tooth pressure should be equally distributed across the entire working face of the gears. To distribute a load of any sort uniformly over several points of support, the most elementary principles of mechanics teach us that we must have recourse to a self-adjusting floating lever, which is known generally as an equalizing bar. To distribute the weight of a locomotive uniformly on the driving wheels, the suspended part rests on equalizing bars, which in turn rest on the journals of the axles. To apply the brakes uniformly to the opposite wheels of a vehicle the braking force must be transmitted through an equalizing bar.

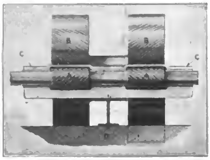

Fig. 3.—Diagram of Westinghouse gear.

Considering that these propositions are so entirely axiomatic, it is strange that engineers could ever have imagined that in a set of gearing the tooth pressure could be distributed uniformly across the working face of a long slender pinion without some construction that would be more or less the equivalent of an equalizing bar.

The pinion of a reduction gear for use in connection with a marine steam turbine must be long, because a wide face is necessary to transmit the large power required. It must be slender because a comparatively small diameter is demanded in order that, at the high rotative speed, the pitchline velocity may be within reasonable limits. When the teeth of a long slender pinion are loaded uniformly across the working face, the pinion is *twisted*.

For simplicity let us assume that the large gear is cut with straight teeth. If the pinion is to run in rigid bearings, in perfect alignment with the shaft of the large gear, and if the tooth pressure is to be uniform across the working face, it is evident that the teeth of the pinion, instead of being parallel with the axis, should be cut on a slight spiral, so that the twist in the pinion due to the load would just straighten out this spiral, and bring the teeth parallel with the axis. Obviously this would not be a practical solution, as the spiral in the pinion teeth would be correct for one load only. The logical thing to do is to let the pinion teeth assume whatever spiral they will, and to support the bearings so that the axis of the pinion may adjust itself to accommodate the angle of the spiral into which the teeth are twisted. It is well known that a spiral gear will operate satisfactorily in mesh with a straight gear, provided the axes stand at the proper angle with each other.

To illustrate, let Fig. 1 represent a long slender pinion with straight teeth cut accurately in line with the axis *AB*, and which is to mesh with a large gear having straight teeth, and its axis parallel to *AB*. If the tooth pressure is to be uniform across the face of the pinion, the latter will twist, and the teeth will take the position indicated in an exaggerated manner by the dotted line. Then, if the gears are to mesh properly, the end *A* will have to raise slightly, and the end *B* lower slightly so as to bring the dotted line into the position now occupied by the line *AB*, and this is what the floating frame allows to take place. If the pinion were supported in fixed bearings, it could not adjust itself when loaded, and consequently the tooth pressure would be concentrated within a short distance at the driven end of the pinion.

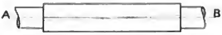

Fig. 1.—Twisting of a long slender pinion.

Again, take the case in which the axes of the gear and pinion are in the same plane, but not adjusted to absolute parallelism. In Fig. 2, let *A* and *B* represent the two ends of the pinion, and *C* and *D* the corresponding ends of the gear. If the center distance between *A* and *C* is less than the center distance between *B* and *D*, then when the teeth are in contact at the end having the shorter center distance, there will be no contact at the other end so long as the axis of the gear and pinion are confined in the same plane. In order to get tooth contact across the entire face of the gear the end *A* of the pinion must lower slightly and the end *B* must raise a little. The floating frame instantly and automatically brings about the required adjustment.

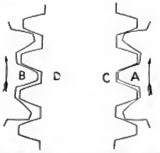

Fig. 2.—Position assumed by teeth at ends of pinion.

Here then are two sets of conditions which require the action of the floating pinion frame to secure proper tooth action, and these conditions are entirely independent of the degree of accuracy with which the teeth may be cut. It is hopeless to expect to get ideal operation with rigid pinion bearings merely by accurate workmanship and fine adjustments, for the reason that the adjustments are variable, and on that account must be effected automatically. For simplicity, we have assumed that the teeth were straight. The same reasoning applies, however, to the helical teeth commonly used on these gears.

The broad idea of the "floating frame" was conceived by the late Rear-Admiral George W. Melville and Mr. John H. Macalpine, who were associated as consulting naval architects and engineers, and who had been for several years engaged in making for Mr. Westinghouse a comprehensive investigation of the application of steam turbines to the propulsion of ships. Mr. Westinghouse, recognizing its importance, and the soundness of the principles on which it was based, undertook to demonstrate its value and practicability.

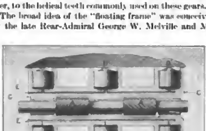

Fig. 5.—Double acting floating frame.

It is not necessary to rehearse the story of the installation of a 6,000 horse-power experimental plant, and the exhaustive tests to which it was subjected. It is sufficient to say that this demonstration convinced engineers that the largest powers could be successfully and efficiently transmitted through properly constructed toothed gearing. It did not, however, convince them that the success of the installation was due to the floating frame. It is only since they have endeavored to dispense with this feature that they have come to recognize that the floating frame was the essential feature that converted failure—or at best, mediocrity—into success.

The Melville and Macalpine design is illustrated diagrammatically in Fig. 3, where *AA* is the double helical pinion and *BB* is the large gear. The pinion shaft is supported in three bearings in the frame *C*. This frame is supported at its center by a section of I-beam *D*, which is fixed to the floor of the gear casing.

It will be seen that if the pinion shaft is flexibly connected to the shaft of the driving turbine, the elasticity of the supporting member *D* will allow the frame *C* to tilt in a clock-wise, or counter clock-wise direction to whatever extent is necessary to secure a proper alignment of the bearings of the pinion with respect to the bearings of the main gear.

While the Melville-Macalpine design fully demonstrated the correctness of the theory of the floating frame, it was soon seen that the essential principle might be more advantageously applied by supporting the pinion frame hydraulically. The advantages of the hydraulic support are three-fold. First, the removal of all direct metallic connection between the floating frame and the gear casing, eliminates in a large measure the noise of operation. Second, the hydraulic medium, being constantly circulated, contains a small amount of air entrained with it, which has a valuable cushioning effect that is not only further conducive to quiet running but which also gives a degree of elasticity to the system that will prevent the rapid contacting of the teeth from producing a hammer blow effect that might eventually result in pitting or crystallization. Third, the hydraulic pressure automatically adjusts itself in direct proportion to the torque, so that by the addition of suitable indicating instruments, the gear becomes the most accurate dynamometer yet devised for the measurement of large powers.

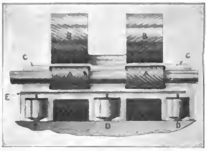

Fig. 4.—Single acting hydraulic floating frame.

The Westinghouse design is illustrated diagrammatically in Fig. 4. As in Fig. 3, *AA* is the double helical pinion, *BB* the driven gear, and *CC* the frame carrying the pinion shaft bearings. In the lower side of the pinion frame are three cylinders with pistons *DDD* which rest on a suitable beam or ledge in the gear casing. *E* is a passage communicating with all of the cylinders. It is evident that if fluid under sufficient pressure be introduced at *E*, the pinion frame *C* will rise and will literally float on the fluid contained in the cylinders. It is also evident that the lift of the pinion frame may operate a relief valve on the fluid pressure system in such a way as to maintain the pressure in direct ratio to the load on the floating frame.

If in the arrangement shown in Fig. 4, the direction of rotation is such that the upper teeth in the pinion are moving toward the observer, the resistance offered by the gear *BB*, will cause a downward thrust on the floating frame *C*, and the relief valve in the fluid pressure system will maintain the pressure in the hydraulic cylinders at the exact point required to balance the weight of the floating frame, plus the downward thrust due to the tooth pressure between the gear and the pinion. If the load is increased, the downward thrust on the pinion frame is increased and the pinion frame is depressed slightly, closing the relief valve in the fluid pressure system sufficiently to restore equilibrium. Conversely, if the load decreases, the pinion frame rises slightly, opening the relief valve, and relieving the excess pressure in the hydraulic cylinders, thus automatically bringing the system into balance again. From the foregoing, it will easily be seen that the pressure in the hydraulic supporting cylinders is at all times an accurate index of the intensity with which the gear is working. The relief valve on the fluid pressure system is opened by a device that multiplies the movement of the floating frame so that the total travel of the latter over a range of load between full capacity and zero is only a few thousandths of an inch.

Inasmuch as the three supporting cylinders are in free communication with each other, the pinion frame is free to align itself in such a way as to bring about an even distribution of tooth pressure across the entire working face of the gear. The central cylinder is somewhat larger than the two others, and its piston acts as a pivot, on which the floating frame is balanced. The tilting of the frame required to bring about proper alignment does not therefore alter the height of the central part of the frame, from which point the relief valve regulating the fluid pressure in the cylinders is controlled.

The arrangement of supporting cylinders illustrated in Fig. 4, is single acting only, and consequently would not be sufficient for a gear that must operate in either direction, as is required in marine service.

When the direction of rotation is reversed, the direction of the thrust on the pinion frame is reversed, and consequently there must be another set of supporting cylinders on the opposite side of the floating frame. The sketch Fig. 5, illustrates the arrangement with two sets of hydraulic cylinders with their pistons *DDD* and *D'D'D'* bearing against suitable abutments in the gear case.

If the direction of rotation is such that the top of the pinion is moving toward the observer, there will be a downward thrust on the frame *C* which will be supported by the pressure of the fluid above the pistons *DDD*. If the direction of rotation is reversed, there will be an upward thrust on the frame *C*, which will be resisted by the pressure of the fluid beneath the pistons *D'D'D'*.

It is evident that the fluid pressure behind the supporting pistons could be maintained by means of a pressure pump discharging into the passage *E* and *E'* through a flexible connection. Fortunately, however, there is a much simpler means which obviates the necessity for the added complication of auxiliary pumping apparatus.

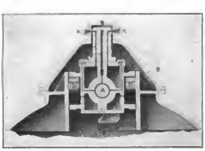

Fig. 7.—Section of double floating frame.

For a long time it has been known that if oil is introduced into a rotating journal at the point of least pressure, and a means of egress is provided at the point of maximum pressure, the journal will have a decided pumping action, and will build up an oil pressure substantially equal to the maximum bearing pressure. For example, let Fig. 6 represent a rotating journal in which the pressure is downward, and the direction of rotation is indicated by the arrow. The maximum bearing pressure will be at the bottom of the journal, and the minimum pressure will be at the sides, especially if the bearing is cut back a trifle on the sides, as is common practice. If a hole be drilled through the bottom of the bearing, and piped to a pressure gage *B*, then when oil is introduced at *A* it will be found that the gage *B* will register a pressure practically equal to the pressure at the bottom of the bearing.

While, as stated above, this fact has been known in a general way for many years, no one appears to have endeavored to make any practical use of it, or to determine the quantity of oil that might be pumped in this manner. In connection with the development of the hydraulically supported pinion bearing frame this pumping action was exhaustively investigated, and it was found that, by suitably proportioning the bearings and supporting pistons, the former could deliver an ample supply of oil at a pressure sufficient to support the floating pinion frame when the gear is transmitting its maximum power.

Fig. 7 is a cross section through the floating pinion frame at the middle bearing. *A* is the pinion shaft, which in this instance is located directly above the main gear shaft. *B* denotes the upper part of the gear case. *C* is the floating frame and *D* and *D'* are two of the opposite supporting pistons. *E* is an upwardly projecting arm with oil passages *F*, *F'* and *G*. *HH* and *H'H'* are oil chambers extending throughout the length of the floating frame, and communicating with all three of the hydraulic cylinders on either side. The sections indicated by the letters *H* and *H* are not two separate chambers; what looks like a dividing wall is only a boss or post through which the oil passage leading the high pressure oil from the bearing is drilled. Similarly *H'* and *H'* constitute a single chamber. *K* and *K'* are the valves which automatically regulate the oil pressure, the details of which are shown to a larger scale later on. *L* is a pivoted link connecting the floating frame to the side of the gear casing, so that when the floating frame moves sidewise slightly in accommodating itself to the load, the upper end of the arm *E* will have a positive and considerably magnified corresponding movement.

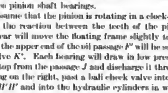

Fig. 6.—Pumping action of journal illustrated.

The operation is as follows: Low pressure oil is introduced into the upper end of the passage *G* in the upwardly projecting arm *E* through a connection that will be described in detail later. The oil passes down through *G* into the passage *J* which communicates with the top of all three pinion shaft bearings.

If we assume that the pinion is rotating in a clock-wise direction, the reaction between the teeth of the pinion and the gear will move the floating frame slightly to the right, and the upper end of the oil passage *F'* will be sealed by the valve *K'*. Each bearing will draw in low pressure oil at the top from the passage *J* and discharge it through the opening on the right, past a ball check valve into the chamber *H'H'* and into the hydraulic cylinders in which the supporting pistons *D'* are located. Since the exit of the passage *F'* is sealed by the valve *K'*, the oil pressure will build up behind the pistons *D'* until it just balances the side thrust of the floating frame corresponding to the load carried at the moment. The instant this pressure is exceeded, the pinion frame is forced slightly to the left. This movement causes the upper end of the passage *F'* to become unsealed by the valve *K'*, and allows the surplus oil to escape into the gear case from whence it is returned through the lubricating system to the passage *G*. The valve *K'* throttles the discharge from *F'* sufficiently to maintain the pressure behind the pistons *D'* constant at the degree required to balance the thrust of the pinion frame. If the load on the gear increases, the arm *E* moves slightly to the right, throttling the discharge from *F'* sufficiently to raise the oil pressure behind the pistons *D'* to the point where the system will be in balance again. Conversely if the load on the gear is decreased, the arm *E* moves slightly to the left, reducing the throttling of the discharge through *F'* so that the pressure behind the pistons *D'* is lowered until it just balances the decreased thrust of the floating frame.

When the direction of rotation is reversed, the action is just the same, except that the valve *K* and the oil passages and supporting pistons at the left, come into play.

Fig 8 is an enlarged section through the pressure regulating valve box, showing the details of the valves *K* and *K'*. The valve chambers contain simple sliding sleeves *M* and *M'*. These sleeves have shoulders and are held against corresponding shoulders in the valve boxes by springs bearing against the valve chamber covers. When the reaction of the pinion teeth causes the arm *E* to move to the right, the flat machined surface surrounding the outlet of the passage *F'* comes up against the end of the sleeve *M'* and prevents the oil from escaping from *F'* into the gear case. The sleeve being supported elastically by the spring, can yield slightly so that there will be no hammering action between the arm and the sleeve, as might be the case under rapid increase of load if the contact were rigid. As the oil pressure builds up beyond the point required to balance the thrust on the floating frame, the arm *E* moves to the left. The contact between the arm *E* and the sleeve *M'* is soon broken by reason of the latter coming up against the shoulder in the valve chamber, leaving an annular opening through which the surplus oil escapes into the gear case. The width of the opening thus formed adjusts itself automatically so as to maintain the oil pressure at exactly the pressure required to balance the thrust on the floating frame. If the pressure in *F'* tends to rise too high, the arm *E* recedes farther from the sleeve *M'* and makes the discharge opening larger. If the pressure tends to drop, the arm *E* approaches the sleeve *M'*, reducing the area of the opening and throttling the discharge sufficiently to maintain the required pressure.

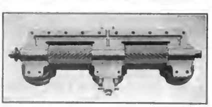

Fig. 9.—Showing lubricating channel in floating frame.

The sleeves *M* and *M'* could, of course, be replaced by solid plugs, but they would be subjected to a considerable unbalanced oil pressure which would necessitate the use of inconveniently stiff springs to support them. By making these members hollow, they are practically balanced as regards oil pressure and the springs need only be stiff enough to insure that the sleeves are held positively in contact against their corresponding shoulders.

The principal advantage of the hollow sleeves is that the valve chambers are always full of oil at the same pressure as obtains in the system, and these valve chambers are consequently most convenient stationary points for attaching pressure gages *O* and *O'* for indicating the oil pressure in the hydraulic supporting cylinders. *N* is a pointer, the position of which indicates whether or not the pinion frame is floating properly. The position of this pointer may be observed by removing a small cap from the top of the valve box.

From what has been explained regarding the automatic regulation of the pressure of the oil which sustains the thrust of the floating frame, due to the reaction of the tooth pressure between the pinion and the gear, it will readily be perceived that the pressure of the oil is an exact measure of the force that is at the moment being exerted at the pitchline of the gears. This force multiplied by the pitchline speed in feet per minute and divided by 33,000 gives the horse-power that is being transmitted. Hence, by noting the pressure registered by the pressure gage *O* and *O'*, shown in Fig. 8 only a very simple calculation is required for calculating the power that is being developed. By connecting to the gear a continuous speed recorder, and a recording pressure gage, we may obtain charts from these instruments which will constitute a continuous log of the power developed over any extended period of time.

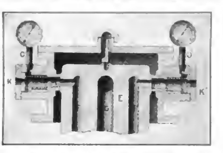

Fig. 8.—Section through pressure regulating valve box.

The gages *O* and *O'*, Fig. 8, may be located at any distance from the gear itself. When the gear is running, only one of the two gages indicates pressure. A reversal of the direction of rotation of the gear shifts the pressure reading to the other gage. If these gages were located on the bridge, the officer on duty could determine at a glance the direction of rotation of the turbine and the intensity with which it was working. These gages would also indicate unerringly the degree of promptness with which the engine room force carried out the instructions telegraphed from the bridge.

With a ready and accurate means of determining the power exerted, experience would doubtless indicate many ways in which this information could be utilized in detecting wastes and effecting important economies. For example, increased coal consumption without increased power would call for prompt investigation of the condition of the boilers, engines and auxiliaries. On the other hand, a comparison of the power developed and the speed of the vessel would avoid the necessity for any conjecture as to when it might pay to dock the ship for a general cleaning of the hull, and an examination of the propellers.

To avoid the necessity for absolutely rigid alignment between the turbine and gear, they should be coupled together by a reasonably long flexible shaft. In order to obtain this desirable connection, without sacrificing any space, the pinion shaft is made hollow, and the flexible driving shaft extends into the bore of the pinion shaft and is fixed to the latter at the end furthest away from the turbine. By this simple expedient the gear may be set close to the turbine, and still have the advantage of a connecting shaft of considerable length.

The coupling between the turbine shaft and the flexible driving shaft is so constructed as to allow the pinion to have a self-adjusting endwise motion without affecting the longitudinal position of the turbine shaft.

Lightning and Its Dangers*

Precautions To Be Taken and Means of Protection During Thunderstorms

By Sir Ray Lankester, K.C.B., F.R.S.

The killing by lightning stroke on Sunday, June 14th, of seven people, including some little children who were taking shelter on Wandsworth Common against the drenching rain of a thunderstorm, shows that it is necessary to warn the public again and again of the danger which they thoughtlessly incur in thunderstorms—danger which they might to a large extent avoid, if not absolutely escape, by behaving, when caught in a thunderstorm, in accordance with the dictates of knowledge and experience.

These seven victims of the lightning were taking shelter from the heavy rain under the projecting boughs of two fairly large trees. Almost exactly three years ago several people who were taking shelter in an open shed at Epsom under similar circumstances were struck by lightning. All children in schools ought to be warned against seeking shelter in a thunderstorm under any solitary upstanding shed, tree, or group of trees. The danger arises from the fact that the shed or the tree stands out high above the general surface, and its top is the nearest point, for some distance round, to the thunder-cloud, and is likely to "attract" the electric discharge, or to serve as the passage of the electricity from the cloud to the earth. If the tree or the shed or such building were a good "conductor" of electricity, and were fixed deeply in wet earth or water (which is also "a good conductor" of electricity), no harm would be done; the electricity of the earth and of the cloud would quietly adjust themselves by aid of the projecting conductor. That is the service which "lightning conductors" perform. They are metal rods placed in high, prominent positions where they come into relation with the electrically disturbed thunder clouds, and as there is free passage through them to the vast area of deep-lying wet earth and subterranean water, the adjustment between the cloud and the earth is easily and quietly effected. As we say, the electric current "flows" through the conductor to—or it may be away from—the earth. But nothing is more fatal than a lightning conductor which is not properly "earthed." The upstanding metal rod must end below in a great plate of metal sunk in permanently moist earth, or, better, in flowing water. When there is not this regular and sufficient outlet for the electric current, as when a lightning conductor is broken from its "earth" or unprovided with such a base, the current behaves like a pent-up stream let loose, and dashes (so to speak) at and through anything leading ultimately to the soil. It is on this account that trees and wooden sheds are dangerous. They attract the electric current, but are not "good" conductors, and so do not provide a passage to the deep wet earth. The pent-up obstructed electricity takes the form of the "spark," or "lightning flash," instead of flowing quietly away. It is terribly destructive and erratic in its course, bursting and burning living as well as inert things on its way.

It is obvious that since it is dangerous to seek shelter in a thunderstorm under or at the side of a prominent tree, or a solitary shed, on account of their "upstanding" character, so it is dangerous to be yourself the most prominent object on a plain or a hill side during a thunderstorm. More persons are struck and killed in this way than when sheltering under trees. Sheep are often struck and killed when lying open on a hill side in a thunderstorm. What then is man, woman, or child to do when caught in the open in a thunderstorm? They may take shelter in a wood though not under an isolated tree, nor under a long high hedgerow. They should ask for shelter in any available house or cottage which is built for human habitation, and has weathered former storms. Failing these they may (as goats and sheep and cattle do) get under a low-lying rock-face, or into a ditch, or dry hole; or even (if the storm is close round them) lie flat on the ground. It is less dangerous to be wet through than to be dry, since wet clothes may and have before now saved a man's life owing to the fact that they are good conductors, and allow the electric current to pass away without obstruction. It is a very dangerous thing to be out in a thunderstorm, which is close to you, on a golf links, in a boat on a lake or wide river, or on the sea. The larger animals always seek shelter from a thunderstorm.

There are some people in this country who take the attitude of regarding the avoidance of unnecessary exposure in a thunderstorm as unmanly timidity. I have heard of such a one, who maintained that, according to the statistical records, only one person in a million, that is to say, forty persons in a population of 40,000,000, each year is struck by lightning in this country. Therefore, he remarked to his partner, when he was caught in a bad storm on a golf links, that the chance against his being there and then struck by lightning was more than a million to one, for there are 365 days in a year. His partner nevertheless crept under the lip of a shallow bunker and awaited events. The statistician walked half a mile across the deserted links toward the club house, and, when in mid-plain, was struck by a flash of lightning and severely injured, happily not killed. Later he admitted that his statistics had misled him. Very nearly everyone (he now recognized) is in the inside of a well-protected house during a violent thunderstorm. Not 40,000,000 of people are so foolish as to walk about on wide, flat plains over which an electric storm is raging. He admitted that probably not 400 in a year, either by compulsion or foolhardiness, thus expose themselves continuously during the full violence of a near thunderstorm. He now declared that one's chance of escape from being struck by lightning if one were fool enough to face a storm and take no precaution, was accordingly only 400 to 40, or 10 to 1—not nearly so good as the chance of a soldier in the front line of battle escaping death or a disabling wound, nor as the chance of recovery from a "major" surgical operation such as an amputation. A curious confirmation of the fact that ordinary human beings do as a rule seek protection from lightning stroke is seen in the fact that from time to time soldiers marching—in the same way as herds of animals when driven—have been destroyed in large numbers by lightning. Had they not been under military discipline they would have sought shelter.

When you are in a house during a close and immediate thunderstorm you should keep the windows shut and avoid placing yourself between two large and prominent conductors of electricity such as the water pipe or gas main (if your plumber has permitted you to know where they are) and the fire-place. If the house is a detached one or a corner house, and the storm is close, you will be acting reasonably if you retire into the basement until the storm is over. But you must be prepared to put up with criticism from the foolhardy. On the whole, the long rows of houses of fairly equal height in the streets of a great town are about as safe as any place during an electric storm. A railway carriage on the rails is theoretically very unlikely to be "struck by lightning," since the rails are a first-rate conductor. The Eiffel Tower, in Paris, being entirely built of iron, is a huge lightning conductor, and has been photographed in storms with forked lightning playing harmlessly about its head.

The inhabitants of towns are much more frequently struck by lightning than country folk, because living as a rule in the protection of the streets, they have no traditions and habits to guide them when they are out for a holiday and are overtaken by a thunderstorm on commons or in open country. They are both indifferent to the danger and ignorant as to the conditions under which that danger is greatest, and those under which it is reduced to a minimum. When they go into the country they do not know how to behave in a thunderstorm.

Learned writers on atmospheric electricity and thunderstorms do not trouble themselves to give information as to the precautions which a man should take to avoid being "struck," and what positions are the safest and what the most perilous. On the other hand, they have carried the knowledge of how to protect buildings by aid of lightning conductors to such a point that it is now possible to build a powder magazine which is practically safe from danger in any thunderstorm. This is effected by applying a network of conducting wire over its surface connected to upstanding metal rods, the bases of which are sunk in permanent subterranean water. The protection of property is more remunerative than the protection of human life.

It is important that everyone should be able to judge of the nearness or distance of a thunderstorm. The sound of thunder caused by the heating and sudden expansion of the air by the great electric spark which we call "a flash of lightning" travels a mile in 5 seconds. When there is an interval between the flash and the sound of the thunder of 2 seconds or more, the storm is for the time being at a safe distance, but when the interval is only a second or less the storm is close, and any prominent object near, or you yourself may be "struck."

The sparks an inch or two long which may be drawn from the brass collector of an "electric machine" are similar to the great electric sparks which pass as "forked lightning" from cloud to cloud or from a cloud to the earth. The little sparks of the electric machine make a sharp crackling noise, and may be made to perforate and traverse thin glass, leaving a hole to mark their passage. They are but 2 inches long. The spark which we know as "forked lightning" varies from 100 yards to a mile in length, and in some cases has been estimated to have been 10 miles in length. Its destructive power and the noise which it makes are in proportion to this difference of size. The ground is often "struck" by the lightning spark, and in sandy soils curious tubes of fused sand of some feet in length are sometimes found, which have been caused by the penetration of the lightning into the ground. They are called "fulgurites." The destruction caused by lightning is due more to the conflagrations which it starts than to the disruptive and bursting action of the current, serious as that is. Until the use of lightning conductors was introduced little more than 150 years ago, church towers and steeples, and, in fact, every large and prominent building, was destined to be struck by lightning and more or less completely destroyed in the course of a few centuries. The cathedrals and churches of this and other countries have been, in the course of history, repeatedly struck by lightning and often burnt to the ground. Though the lightning flash is a very difficult thing to deal with and takes the strangest and most unexpected paths when it strikes a house or other building, yet it is the fact that the danger of destruction of buildings by lightning has been greatly reduced. Competent electricians all over Europe are occupied in the endeavor to improve our present methods of protection by "lightning conductors."

There are several varieties of "lightning," or visible electrical discharges in our atmosphere. They are: (1) The line-like, wavy, often branching "forked lightning"; (2) sheet lightning; (3) St. Elmo's fire and the "brush" discharge; (4) ball lightning (also called "fire-balls" and "thunderbolts"—a name applied also to meteoric stones); (5) the Aurora Borealis (or "Polaris," since it occurs at both poles of the earth). The "zodiacal light" is not, as has been supposed, an electric discharge. Forked lightning is the familiar, dangerous spark-like form of discharge, and "sheet lightning" is merely the reflection on clouds of forked lightning, too distant to be itself visible. St. Elmo's fire is a continuous brush-like silent discharge given off sometimes at the masthead of ships. A similar discharge is seen on mountain tops, and is described by Alpine climbers. It was seen and studied at the observatory on Ben Nevis a few years ago. The points of the roof, the poles, and even the hats on the heads of the observers (as sometimes the ice-axes of Alpine climbers) gave off this alarming, but harmless, luminous electric glow. Ball electricity is a very terrible and uncommon thing. It has, however, been often witnessed and described. During a thunderstorm a luminous ball from a few inches to a yard in diameter is seen moving near the surface of the ground. It may rise and fall and even enter an open door. Usually when it touches any obstacle it detonates, and causes enormous destruction, like a dynamite bomb. The Aurora Borealis, or "Northern Lights," better called Aurora Polaris, is a form of electric discharge in our atmosphere which occurs only near the Arctic and Antarctic regions. Its occurrence is not accounted for. It consists of curtain-like scintillations of colored light, and is accompanied by a hissing or rustling sound, and may be related in nature to the brush-like discharge of St. Elmo's fire. The spectrum of the aurora has been examined, and shows that it contains the gases of our atmosphere (including the rare new gas krypton) in an incandescent condition.

There are fewer thunderstorms and also fewer people killed by lightning annually in northern countries than in southern. This statement must, however, be qualified by the observation that thunderstorms are almost unknown in two widely separate southern lands, namely, Egypt and Peru. In the United Kingdom a much smaller number of persons (in proportion to population) is annually killed by lightning than in the United States of America or in France. The number of deaths from lightning stroke which occur in rural districts is ten times more numerous in proportion to population than those which occur in towns. This seems to be due to the protection afforded by the streets. Whether the smaller death rate from lightning in the United Kingdom as compared with the United States of America and with France is due to the less violence and frequency of thunderstorms in our islands, or to greater carelessness, and also to greater exposure in outdoor work in wild regions in the two latter countries, does not appear.

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* From the London *Daily Graphic*.

Two erroneous notions are generally heard of when a disaster such as that which occurred on Wandsworth Common is recorded. One is, that certain species of trees are more dangerous as shelter in a thunderstorm than others. It is said that more people are killed by lightning under oak trees and elm trees than under beech trees, and that no one has ever been killed under a birch tree! An attempt is made to connect this with the nature of the wood of these trees. But the facts are not established, and it is probable that the frequency, height, and usual position occupied by each of these trees are the causes of their apparently favoring or not favoring the deadly activity of a flash of lightning. The second erroneous notion is, that the lightning often prints off onto the body of a person struck by it, a picture, a sort of photograph, of the tree under which he or she was standing. Such tree-like pictures are often found on the skin of persons struck by lightning, and are caused by the dissolving of the colored corpuscles of the blood in the branching tree-like blood vessels of the skin, where the lightning has reached it. Sometimes an old tattoo mark (in the case of a soldier or sailor) gets mixed up with such "extravasations" of blood from the tree-like branching blood vessels, and so gives rise to marvelous stories as to the pictures wrought on the victim's skin by the lightning.

The Law of Distances of the Planets and Satellites

Some astronomers still adhere to Newcomb's opinion, that the distances of planets and satellites from their centers of attraction are not connected by any law. It is true that valid objection can be made to Bode's empirical law, according to which the approximate distances of the planets from the sun can be found by multiplying by 0.3 each term of the series: 0, 1, 2, 4, 8, 16, 32, etc., and adding 0.4 to the product. The fact that the law gives 38.8, instead of 30, for the distance of Neptune, is of small importance, for the law probably does not apply to the retrograde region of the system, in which Neptune is situated, as its retrograde rotation shows.

But Bode's law is contradicted by the "Mécanique Céleste" of Laplace, which constitutes a far more serious objection. In fact, Bode's law gives a very accurate value (5.2) for Jupiter and a very erroneous value (10 instead of 9.5) for Saturn. Any change in the distance of these two great planets that may have taken place in past ages must have been caused by their mutual attraction, but the maximum effect of this attraction, according to the "Mécanique Céleste," would be 14 times less than the departure of Saturn from Bode's law.

In presenting these facts during the course of an article in *La Nature*, Emile Belot points out that: "Slight discrepancies between an empirical law and observed facts do not afford a sufficient reason for rejecting the law. Kepler's three laws are only approximate. If Newton had taken, with regard to them, the skeptical attitude referred to above, he could not have proved the universality of gravitation.

"The only difference that exists between Kepler's laws and the law of planetary distances is that astronomers can easily explain the former, but have not been able to explain the latter, by Newton's law of universal gravitation. This failure, however, is not a sufficient reason for rejecting the law of distances *a priori*."

By adapting the ideas of Descartes to modern science, M. Belot assures his readers that he has succeeded in constructing a new vortex cosmogony, and in demonstrating a law of distances which is simpler and more accurate than that of Bode. This new law was submitted to the Académie des Sciences in 1905 by H. Poincaré.

The subjoined table of calculated and observed distances "leaves no room for doubt of the reality of this law," in M. Belot's opinion, and "it also shows an astonishing correspondence between the solar system and the system of Saturn."

M. Belot continues: "The *sudden* formation of all the planets at their present distances would be incomprehensible on Laplace's hypothesis of a single nebula, but it is entirely natural in my vortex cosmogony, which begins with the collision of two nebulæ, one vortical, the other amorphous, and endowed only with a movement of translation. In this collision, analogous to those which produce new stars, the vortical nebula is thrown into vibration and projects into the amorphous nebula as many concentric sheets as there are centers of vibration.

"In each of these planetary sheets, where the velocity of translation is diminished by the resistance of the medium, there is only one level, and in this level only one point, where the tangential velocity is opposable to the relative velocity of the vortical nebula. At these points only, in all of the sheets simultaneously, are formed vortices, the nuclei of future planets. This rapid and simultaneous expansion was observed in 1901, in the nebulous rings of Nova Persei.

"A century ago Lagrange and Laplace believed that they had proved, from the series given in the "Mécanique Céleste," the invariability of the mean distances of the planets and, consequently, the stability of the solar system. H. Poincaré, however, has shown that these series, instead of being convergent, are divergent, so that the stability of the solar system remains uncertain. But the law of distances removes this uncertainty. If, since the original formation of the universe, the distances of the planets had been changed by tidal action, mutual attraction, etc., and if these perturbations had accumulated, the results would differ for large and small planets, and for planets near and remote from the sun. In short, no law of planetary distances would now be recognizable.

"The fact that this law has existed unchanged from the beginning proves that the stability of the solar system has persisted during 100 or 200 million years, and is in no danger of being destroyed in the future, unless the system should come too near the nebula in Andromeda, which is approaching us with the menacing velocity of 200 miles per second.

"Thus the certain existence of the law of planetary distances proves at once the stability of the solar system and the cosmogonic insignificance of tidal action and the mutual attraction of planets or satellites."

EXPONENTIAL LAW OF PLANETARY DISTANCES.

$r_n - a = c^n$.

(r_n denotes distance of n the planet, a, radius of generating vortex, c, a constant.)

SOLAR SYSTEM

$r_n - 0.28 = 1.883^n \quad \frac{1}{214.45}$

No.		Distance Calculated	Distance Observed.	
1.	Zodiacal ring	0.2898	Observed	
2.	Zodiacal ring	0.2915	Observed	
3.	Zodiacal ring	0.3055	Observed	
4.	Zodiacal ring	0.3595	Observed	
5.	Mercury	0.3864	0.3870	
6.	....	0.4878	0.3870	
7.	Venus	0.6714	0.7233	
8.	Earth	1.017	1.0000	
9.	Mars	1.668	1.5236	
10.	Ceres, etc.	3.881	2.75	
11.	Jupiter	5.201	5.2028	
12.	Saturn	9.546	9.5388	
13.	Uranus	17.728	(19.183)	(rétro)
14.	Neptune	33.183	(30.055)	(rétro)
	SYSTEM OF JUPITER. $r_n - 0.705 = 1.7175^n$.			
1.	V	2.5125	2.55	
2.	.	3.7447	2.55	
3.	I	5.8713	5.933	
4.	II	9.4964	9.439	
5.	III	15.7295	15.057	
6.	IV	26.462	26.486	
7.		44.870	26.486	
8.	.	76.538	26.486	
9.	VI VII	130.835	160–167	
10.	....	221.435	160–167	
11.	VIII	384.37	357	(rétro)
	SYSTEM OF SATURN. $r_n - 0.1 = 1.311^n$.			
1.	Ring C	1.411	1.2–1.5	
2.	Ring B	1.819	1.5–1.95	
3.	Ring A	2.353	1.95–2.3	
4.	Mimas	3.054	3.07	
5.	Enceladus	3.974	3.94	
6.	Tethys	5.177	4.87	
7.	Dione	6.756	6.25	
8.	Rhea	8.826	8.73	
9.	Rhea	11.546	8.73	
10.	Rhea	15.098	8.73	
11.	Titan	19.762	20.22	
12.	Hyperion-X	25.877	24.5–24.2	
13.	Hyperion-X	33.90	24.5–24.2	
14.	Hyperion-X	44.40	24.5–24.2	
15.	Japetus	58.18	58.91	
15.	Japetus	58.18	58.91	
19.	....	171.67	58.91	
20.	Phebe	225.03	(214)	(rétro)
	SYSTEM OF URANUS. $r_n - 4.9 = 1.496^n$.			
1.	....	6.396	(214)	(rétro)
2.	Ariel	7.138	7.04	
3.	....	8.245	7.04	
4.	Umbriel	9.898	9.91	
5.	....	12.380	9.91	
6.	Titania	16.105	16.11	
7.	Oberon	21.66	21.52	

Alcohol from Wood

The theorist's knowledge of the chemical structure of cellulose, grape sugar, and alcohol naturally leads him to desire to saccharize cellulose by treatment with acid, that is, to invert it into grape sugar, and then to convert the sugar obtained in this way into alcohol by fermentation. Since Braconnot demonstrated in 1819 that fermentable sugar is formed when substances containing cellulose are treated with acids many chemists have devoted themselves to experiments to find a good technical process for the obtaining of spirits from wood and other substances containing cellulose. Up to the end of the last century, however, no real technical success had been obtained in this field. There has been renewed activity in this branch of research for the last ten to fifteen years and great advances have been made, especially during the past five years, in our chemical knowledge of cellulose. A large number of cellulose factories produce alcohol by working over their waste liquors. Much larger quantities of alcohol can be obtained from the wood waste of sawmills in countries rich in timber. In discussing the extraction of alcohol from wood waste, Dr. R. Ditmar says in the *Umschau*:

"Both in the United States of America and in Canada there are sawmills which keep great fires going day and night to rid themselves of the wood waste. America seems to be the land in which the problem of extracting alcohol profitably from wood waste will first find a practical solution. The labors of European investigators form the basis of the experiments undertaken there. The process originally used was Classen's, described in the *Umschau* (1905, No. 26), in which the wood waste was treated with sulphurous acid. The details of the process were worked out in Herr Geheimrat Classen's laboratory at Aachen. American capitalists then built a laboratory at Highland Park near Chicago, and as good results were obtained here the Classen Lignum Company, which had acquired the Classen patents, built a factory for manufacturing wood alcohol on a large scale at Hattisburg, Mo. Wood shavings and sawdust were put into an iron digester lined with lead, the digester being a cylindrical vessel 10 meters long and 1 meter in diameter set in a horizontal position. The contents were moistened with a nearly saturated aqueous solution of sulphurous acid. The digester, which could hold about 1,800 kilos of wood waste, was then closed and set in rotation while the contents were heated to 150 deg. Cent., and the pressure inside rose to 7 atmospheres. After four to six hours the contents of the cylinder were taken out and washed with water. The sugary liquid thus acquired was fermented with yeast. About 8 litres of pure alcohol should be obtained from each 100 kilos of dry wood waste."

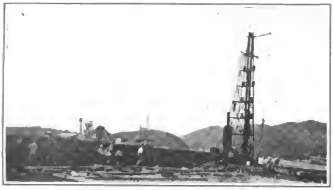
Various technical difficulties arose in the practical working of the process. Consequently, the Hattisburg factory was only run for a short time. After this the Classen process underwent two different forms of development in America. A branch of the Classen Lignum Company, called the Classen Chemical Company, built a new factory at Hullock in the State of Washington which made use of a somewhat modified process.

Further experiments were also made, independently of the Classen Company, by two American engineers, Ewen and Tomlinson, who were acquainted with the Classen process at Aachen. Their process differed from Classen's in the construction of the digester. The good results obtained at a laboratory built near Chicago at the expense of the Wood Waste Products Company—where according to the investigations of Prof. Ruttan of Montreal 8.5 liters of alcohol have been obtained from 100 kilos of dry wood substance—led to the founding of a new company. This organization, the Standard Alcohol Company, after obtaining Ewen and Tomlinson's patents built a large factory for making wood alcohol at Georgetown, S. C. Dr. Ditmar says further in his summary:

"The first mentioned factory at Georgetown came into the possession of the E. J. du Pont de Nemours Powder Company. This company controls almost the entire manufacture of powder and explosives in the United States and uses such enormous quantities of spirits in its numerous factories scattered over the entire country, that, although the factory at Georgetown produces more than 6,000 liters of spirits per day, it is regarded by the E. J. du Pont de Nemours Powder Company merely as an experiment station. It is, consequently, of the greatest importance to the company to produce the spirits it needs as cheaply as possible, and it is easy to understand that it is working with the greatest energy to perfect the manufacture of wood alcohol, and shrinks from no sacrifice in seeking the desired end. The factory at Georgetown, an old seaport of South Carolina, is in the immediate vicinity of three large saw mills belonging to the Atlantic Coast Lumber Company. Formerly these mills threw the wood waste that was not used in heating the boilers into the water or spread it on the surrounding fields; when this proved unsatisfactory the waste was burnt up in great furnaces. At the present time, 220,000 kilos of wood waste are worked over daily into alcohol."

The original Ewen and Tomlinson process used in the factory at Georgetown has been somewhat changed, so that sulphuric acid, not sulphurous acid, is now used in saccharizing the cellulose.

It would seem from these experiences in the United States that the manufacture of alcohol from wood waste may before long become a successful competitor of the ordinary distillation process.



Riveting the sheet piling of the new St. Thomas dock.

Piling of the new dock. At right-hand side is seen the iron pile facing.

The New Coaling Dock at St. Thomas

The First Unit of Extensive Harbor Improvements

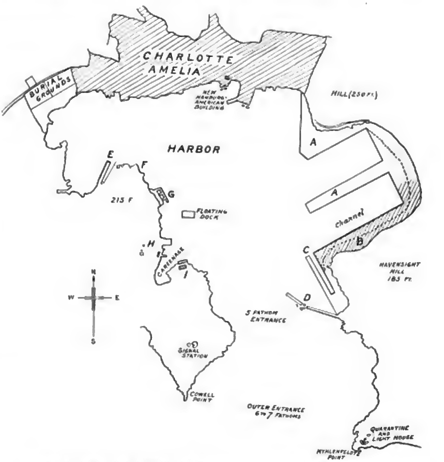
By C. T. Mason

Believing that the island will benefit through the opening of the Panama Canal, the Danish people, as shareholders in a syndicate formed for the purpose, are building at St. Thomas what promises to be the finest coaling dock in the West Indies. It was at first proposed to carry out much more important improvements of the really splendid harbor, by reclaiming all the land at the eastern end and building a dock embankment along the entire shore, with a central pier 2,000 feet long, a drydock 800 feet in length, and a breakwater to further protect the shipping in case of heavy weather from the south. It was found impossible, however, to raise the required $7,000,000 in Denmark, and as only national capital was desired or advisable, the scheme had to be abandoned in favor of the present one. This consists in reclaiming about one third of the land and the erection of a large coaling dock capable of admitting vessels drawing thirty feet of water. The work was begun in April of last year and, at the rate it is being pushed, will be completed by October 31st.

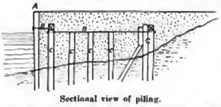
In order to make the approach practicable for vessels of the draft mentioned above, a channel varying from 500 to 400 feet wide is being dredged along the side of the dock. The excavated soil, consisting of sand, clay, and shells, has been used to build up the land required for the operation of the dock and also for filling in the spaces between the piling. This reclaimed land amounts to nearly one hundred acres and more than half a million cubic yards of soil have been employed in the construction.

Filling in with sand dredged from channel.

Casting supporting wall for back rail of coal crane.

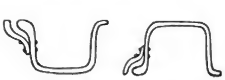


Plan of harbor at St. Thomas, showing location of new dock and improvements.



Sectional view of piling.

A, iron facing; B, iron bolts; C, C, wooden piles, the first and last with a square wooden runner on top.



Larssen system of sheet piling.

As to the dock itself, this has an iron facing of sheet-piling, known as the Larssen system, which consists of trough-like piles, seven eighths of an inch thick, that alternately turn the trough inward and outward, the piles being kept together by the edge of one sliding down in a ridge riveted on the edge of the other. They are kept in place partly by being driven into the solid ground and partly by being bolted to a system of wooden piles on the landward side. These wooden piles, of which over 5,000 were used, are of American yellow pine, averaging from 8 to 14 inches in diameter and from 16 to 50 feet long. The space between the piles will be filled in with soil dredged from the bottom of the channel. The system of iron facing employed has been used to great satisfaction in similar work, particularly at Kiel, but never on such an extensive scale.

When completed, the pier will measure 2,100 feet in length, with a depth along the side of 31 feet and a height above mean sea level of 8.25 feet. Two coal cranes (to begin with) will be installed, each having a capacity of 100 tons an hour. For the lighting and operation of the dock by electricity a power house (built on hardwood piles with a concrete foundation) has been erected, and here a Diesel motor of 300 horse-power has been installed, and another of similar capacity will shortly be added. The lighting will be provided by fifty metallic incandescent lamps of from 200 to 300 candle-power, placed in two rows. A pump house for supplying sea water for cooling the motors has also been put up and connected with the engine rooms. It is expected that the system, besides supplying all the needs of the dock, will also be called upon to furnish the lighting for the city, now illuminated by gas.

It is the intention of the syndicate to provide oil for vessels patronizing the port, and the necessary storage tanks will be erected as soon as the needs of the dock are properly ascertained. The work has been carried out entirely by Danish engineers and mechanics, of whom about fifty were brought out from Denmark; while native labor has found employment to the extent of about three hundred persons, the pay of these natives being 60 cents a day for unskilled hands and $1.25 for mechanics.

The photographs reproduced, and taken expressly for this article, are by Lieut. Olsen, one of the engineers of the syndicate, to whom the writer is indebted for the information given.

The Altitude Record Again Broken

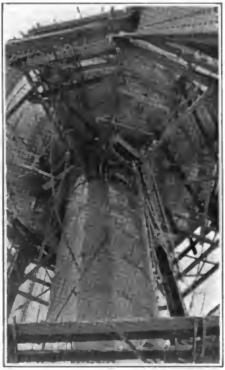
Again the altitude record has been broken, this time by the German aviator Oelrich, who has reached an altitude of 8,000 meters, or 26,250 feet. At 14,800 feet he found breathing difficult, and was obliged to make use of his oxygen apparatus. This, however, did not help him much toward the end of his ascent, and he suffered decided feelings of sickness and giddiness. If greater heights are to be attained, Oelrich asserts that special provision will have to be made for breathing, and also some kind of protection for the body against cold and reduced air pressure.

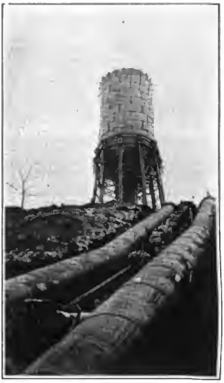
A Surge Tank for Hydraulic Power Plants

A Simple Method of Controlling the Flow of Water in Long Pipe Lines

In hydraulic power plants which are served by long pipe lines between the reservoir and the water wheels, when there is a sudden demand for more power, necessitating an increased supply of water, there will ordinarily occur an interval of time after the valves are opened before the necessary increased flow is established in the pipe line. And on the other hand, when the valves at the turbine are suddenly closed, severe strain is thrown on the pipe line in checking the momentum of the long column of water. To remedy these conditions modern hydraulic engineers make use of a hydraulic regulating device known as a surge tank, which is permanently connected with the pipe line at a convenient point, usually as near the turbines as possible.

Derrick used in erecting the tank.


Riser and tank as seen from below.


Surge tank and pen stocks.

One of the largest surge tanks ever constructed has recently been erected at the plant of the Salmon River Power Company at Altmar, N. Y., to take care of the back pressure or surge loads on a very large pipe line supplying water for power purposes. This line is 9,500 feet long and ranges from eleven to twelve feet in diameter, and the volume of water and the variations in pressure to be handled are exceedingly large.

This great tank is a cylinder with a hemispherical bottom 105 feet in height and 50 feet in diameter, and the 12-foot riser that connects it with the pipe line is 100 feet high, bringing the top of the tank 205 feet above the ground. Close to the power plant there is a section of the pipe line, called the distributor, with which the pen stocks leading to the various turbines are connected, and in this distributor is placed a great cast steel tee, which forms the connection with the riser that leads to the surge tank proper. This riser is 12 feet in diameter, the same size as the distributor pipe, and connects the latter with the bottom of the tank. Within the tank this riser is continued about two thirds of the height of the tank by a section 10 feet in diameter, which in effect divides the contents of the tank into two distinct parts. At its lower end this interior riser is provided with openings, termed differential ports, that form a connection of the space within the riser with the main body of the tank, the function of the ports being to modify the flow of water to and from the tank, and divide the flow between the main body of water in the tank and that within the riser. When there is a demand for more power from the plant, and the valves at the turbine are suddenly opened, the differential ports, by retarding the flow of water from the tank, apply the full accelerating head to the pipe line, and at the same time the tank makes up any deficiency in the volume of water required at the turbines until the flow in the pipe line has accommodated itself to the new conditions. On the other hand, these so-called valves check the rise in pressure more gradually when the load is thrown off. In the wooden flooring at the top of the tank suitable traps are placed to permit of the passage of air during rapid changes of water levels in the tank, which changes are liable to be quite large and of frequent occurrence.

The tank and its fittings are substantially constructed of steel, and it is housed in to protect it from the weather, and provision is made against freezing.

Damascene Steel

According to an article in the *Internationale Zeitschrift für Metallographie*, by W. Guertler, damascene steel contains 1.0 to 1.6 per cent carbon, and consists structurally of extremely small grains of cementite in a ground mass of ferrite. The characteristic appearance and properties of the steel are due to alternations of cementite-poor and cementite-rich zones. Prolonged heating at high temperatures, as recommended in the earlier literature, cannot possibly give the desired result. The most promising method seems to be to heat suitable steel, in which an extremely fine-grained structure has been induced, to a temperature below 700 deg. Cent. for a sufficiently long period. The necessary preliminary structure may be produced by very rapid cooling, or by severe working above the eutectoid temperature.—*Journal of Franklin Institute.*

A Novel Wax Bleaching Plant at Brentford (England) consists essentially of an electrically driven blower, an air cooler, a battery of five ozonizers, and the vessel in which the material is treated. The ozone produced is led to the bottom of the treating vessel, and passes up through the molten wax in fine jets, effecting the bleaching of the wax.

The Riddle of Mars

How the Planet May Be Saving Itself from Death by Irrigation

The planet Mars has a special fascination for the layman as well as for the astronomer, inasmuch as it is probably the only member of the solar system, our own earth of course excluded, on which the existence of animal life is at all likely. What is the character of that life? For the solution of an astronomical problem, circumstantial evidence is all that is available, and certainties can never be available from such evidence alone. Prof. Percival Lowell's views with regard to the nature of Mars's canals and oases were reached mainly by direct observation. Their rhythmic waxing and waning is frequently emphasized, and in "Mars as the Abode of Life" he writes: "Confronting the observer are lines and spots that but impress him the more as the study goes on with their non-natural look. So uncommonly regular are they, and on such a scale, as to raise suspicion whether they can be by nature regularly produced."

The regularity, the character, and indeed the very existence of these minor markings are, however, questioned by some astronomers; an endeavor is therefore now made by Mr. C. E. Housden, a member of the British Astronomical Association, to solve the riddle of Mars from quite a new direction, to-wit: An analysis of and deductions based mainly on terrestrial irrigation experience from the extensive color changes which have from time to time been noticed even in small telescopes in the main features of the Martian disk, the existence of any minor markings being, to begin with, ignored as far as possible. Mr. Housden has set forth his views in a book entitled "The Riddle of Mars," published by Longmans, Green & Co., and from this book the following paragraphs are abstracted by permission.

COLOR CHANGES ON MARS.

When Mars is viewed even through a moderate-sized telescope, three distinct colors can be clearly made out on its disk. These are:

(a) Two comparatively small circular patches of white at its poles.

(b) A broad band of ocher occupying very nearly the entire center of the planet.

(c) Two more or less connected narrower bands of blue-green lying between the white polar caps and the central ocher band.

Examination of the circular patches, which are probably polar snows, has shown that, as they melt, the decreasing caps are bordered by a dark blue band which follows and narrows with the dwindling caps, and can thus be only water. That it is so is now generally granted. This band, however, rapidly disappears, the areas originally occupied by it showing first dark brown and then fading out to ocher, leaving ultimately a small kernel of white bordered by a very narrow blue band in the center of the vast ocher area thus exposed to view.

The snow thus collects for about seven and one half Martian months, is about three such months in nearly all melting off again, and does not either perceptibly increase or decrease during the remaining one and a half months.

The ocher-colored areas on Mars, which do not change to any marked extent, are now generally admitted to be deserts.

The extensive blue-green areas are, it is further now admitted, not "seas," as it was at one time supposed they were. Their coloring is accounted for by two rival theories: The one holds that they are what were once Mars's ocean basins, and that they are, in consequence, depressed areas now covered twice a year with vegetation; and the other, that they are what on earth would practically be permanently frozen swamps. The former view is the more acceptable.

The blue-green all over Mars is at a minimum about mid-January and mid-July of the Martian year, and at a maximum about mid-April and mid-September. If the color changes were due to the freezing and unfreezing of swamps, the changes noticeable in the northern and southern hemispheres should be radically different. The blue-green areas are therefore, without reasonable doubt, mainly depressed areas covered with vegetation which waxes and wanes, the time from minimum to minimum being somewhat shorter in the warmer polar hemisphere, in which the snow is at the time melting, than in the opposite and at the time cooler one.

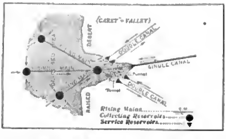


Fig. 1.—Details of flow through a "caret" on Mars.

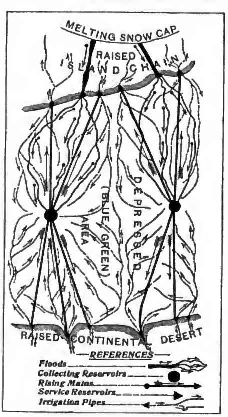


Fig. 2.—The irrigation of a depressed area in Mars's southern hemisphere.

For vegetation to wax and wane year in and year out, successive waterings, either natural or artificial, are needed. But the only water on the planet is at the poles. Hence, that water must be led to the spots where it is needed.

FLOW OF WATER ON MARS.

The polar cap in Mars's southern hemisphere must, at its maximum, be a vast snowfield, as its average diameter is then about 3,000 miles, and the maximum area covered by it about 10,500,000 square miles.

The whole cap (area 10,500,000 square miles), however, practically all melts off in about three Martian months, or say 15,000,000 seconds, or at an average rate of $\frac{105}{150} = 0.70$ square mile per second.

Taking the average depth of water available from the melting of the snow at half a foot over the cap's entire area, due to a 5-foot depth of snow (and a greater depth, owing to the rapidity with which it melts, could not well be calculated on), the rate of flow during the time the cap is melting would be a continuous one of $\frac{1}{2} \times 27{,}878{,}000 \times 0.70 =$ say, 10,000,000 cubic feet per second, or, in its usual abbreviation, 10,000,000 cusecs.

The water from the melting cap cannot drain into a neighboring sea as it does on earth, but must flow away overland to the so-called "seas" (depressed areas) of Mars's southern hemisphere.

With a depth of 2 feet and a water surface slope of 1 in 3,000, the velocity generated on Mars would be 0.84 feet per second, and we should need a series of channels having a combined width of $\frac{10{,}000{,}000}{2 \times 0.84} =$ say 6,000,000 feet, or about 1,200 miles.

To provide artificial carriage in open channels of low depth and low velocity for such a large discharge as 10,000,000 cusecs would be a matter of considerable difficulty; the water set free on the first melting of the southern polar cap must therefore mainly find a natural escape through very flat existing openings having a total combined width of either about 1,200 miles and a 2-foot depth through which the water flows with a velocity of 0.84 feet per second, or a combined width of about 350 miles with a depth of 4 feet and a rate of flow of 1½ feet per second, or something in the neighborhood of these limits.

To make use of the water so locally collected or collecting it would be necessary, as in the case of the southern hemisphere, to pump it from where it is collecting to where vegetation is at the time in full growth all over Mars.

HOW FLOWING WATER IS UTILIZED.

The simplest, and in the long run perhaps the most economical, way in which this could be effected under similar conditions on our own earth, would be to pump the water through water-tight pipes or conduits from the low points at which it is collecting up to service or distribution reservoirs situated on convenient high points within or, preferably, on the margins of the areas to be irrigated, whence it could be carried in the required directions through water-tight pipes under a static head, from which pipes and from smaller pipes branching therefrom, and from still smaller pipes branching from these branch-pipes, the water could be distributed all over the areas needing irrigation, in the form of "regulated artificial rain showers," through mechanical sprinklers worked under a pressure head.

The distribution of water to a depressed area of Mars's southern hemisphere might be somewhat as illustrated in Fig. 2.

The actual continuous flow from Mars's south polar cap is probably a large one—under the assumed conditions, 10,000,000 cusecs—and would need a large number of pipes, taking off, however, from a large number of distribution centers, to allow of the available supply being even only lifted from collecting to service (distribution) reservoirs.

The diameter of each pipe would further be limited by the horse-power which could be economically devel-

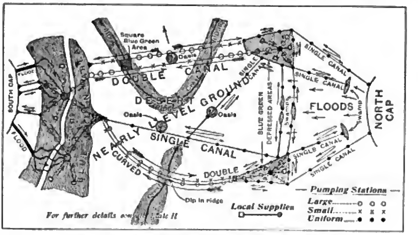


Fig. 3.—Plan illustrating the transport of water across Mars.

oped at each pumping station along it, and could not therefore be very great.

If the pipes are buried underground, the only evidence of the direction followed by the water-conveying pipes (rising mains) would be the pumping stations, many miles apart, on them.

The distribution pipes, under static pressure, leading from the service reservoirs would not show at all.

Assuming, so as to have something definite to work on, that each "rising main" has a diameter of 6 feet, and that the rate of flow through it is Mr. Lowell's ascertained rate of flow from north to south in the Martian canals, viz., 2.1 miles per hour or 3.1 feet per second, the discharging capacity of each pipe would, as the area of a 6-foot diameter circle is 29.6 square feet, be 29.6 × 3.1 = 90 cusecs. As the continuous flow to be arranged for is 10,000,000 cusecs, we should need $\frac{10,000,000}{90}$ = say, 120,000 such pipes for the purpose.

These pipes could be grouped together according to the quantity of water to be raised to each service (distribution) reservoir.

Twenty pipes placed parallel to one another and say 100 feet apart, so as to allow of room for the pumping stations needed on each one, would, if laid in turfed banks and cuttings (so as to allow of these large pipes being graded), or if from any other cause (such as the irrigation for local food supplies of the land lying immediately above them) the line of pipes was rendered visible, if viewed from afar, have very much the appearance of the streaks to be seen on Mars and designated its "canals," inasmuch as it would show a straight, very long, very narrow, and uniformly wide, continuous shading.

Through such a "canal" 100 × 20 = 2,000 feet wide, 90 × 20 = 1,800 cusecs would be continuously pumped.

With a thousand pipes so arranged, the flow could be increased to a continuous one of 90,000 cusecs, and the width of the "canal" would be 100,000 feet, or close on 20 miles.

Now, as such streaks, in some cases over 2,000 miles long and on the average about ten miles in width, have been mapped as traversing in straight lines, both the ocher and blue-green area of Mars in all directions, it is only a reasonable inference that they are due to a somewhat similar cause, and that they mark the directions in which water is being pumped through groups of parallel pipes from generally low-lying to higher points on the planet.

Such streaks do not show until some considerable time after the polar snows commence to melt, and are therefore other than the broad ill-defined ones, which indicate the directions followed by the floods from the south polar cap.

The water raised to convenient points on the northern margins of these southern seas would not only be needed for the irrigation of, say, half the area covered by them and the south island chain, but a fair portion of it, about one half, would have to be pumped right across the intervening desert tract for the irrigation of the blue-green areas of the northern hemisphere, whose total area is somewhat less than a moiety of those in the southern hemisphere. To allow of this being done, we should need a number of "canals" crossing the central Martian desert, and connecting the extensive blue-green areas of Mars's southern and northern hemispheres one with another. These "canals" would have an average length of about 2,000 miles each. On the other hand, the lengths of the "canals" crossing the northern blue-green areas may be put at about 1,200 miles.

The average length of each of the separate sections through which water would have to be pumped from collecting to service reservoirs would thus, at the most, be ¼ (1,200 + 1,200 + 2,000 + 1,200) = 1,400 miles.

Six months later, on the melting of the northern cap, water would have to be similarly conveyed across the central desert from north to south. The amount so available would perhaps, as the maximum area covered by the northern cap is 7,000,000 square miles, be a continuous flow of $\frac{7}{10} \times 10,000,000 = 7,000,000$ cusecs. This is on the supposition that the full amount available could be brought into use.

If out of the 10,000,000 cusecs available from the southern polar cap, we assume that 7,000,000 cusecs will suffice for the irrigation of the blue-green areas in the southern hemisphere and 3,000,000 cusecs for that of the northern blue-green areas, the amount available for transmission from north to south will be 7,000,000 − 3,000,000 = 4,000,000 cusecs, or 1,000,000 cusecs more than from south to north; but another 3,000,000 cusecs would still be needed for the irrigation of the southern seas.

If the intervening desert was a level plain or only undulated slightly, the pumping stations needed along the "canals" would be much the same distance apart and of much the same power, and water could be pumped from south to north, or north to south, through a single "canal," by simply reversing the direction of flow; even if it was necessary to pick up *en route* a small, blue-green area (an "oasis") situated in the intervening desert tract. A single line of pipes ("canals") carried past or through the higher end of the "oasis," from which the water required for its irrigation could be distributed by gravitation, would suffice, and the flow would be somewhat as illustrated in Fig. 3, "single canals."

A double set of pipes would, however, be needed, if the ground over which water has to be pumped is far from level. Appreciable intervening heights would have to be surmounted, and a line of pipes with a different set of pumping stations—powerful ones on the up-grades and smaller ones on the down-grades—provided for the south to north flow and the north to south one, the directions of flow being somewhat as shown in the "double canals" illustrated in the above referred to Fig. 3, the "canal" carrying the north to south flow being probably the wider one of the "double."

In Mr. Lowell's and other maps of Mars are shown many "canals," both single and double, either directly connecting the extensive blue-green areas in the two polar hemispheres together, or more frequently picking up on the way a small blue-green area; and, strange to say, in many instances a "double canal," with one "canal" wider than the other, is used for the latter purpose with, in some cases, the small blue-green area situated exactly between the twin "canals." Two different kinds of blue-green areas are, according to Mr. Lowell's maps, so picked up—small dark, round spots (the "oases" of Mars) and large square areas of a lighter blue-green, as shown in Fig. 3.

From such an arrangement of pipes ("canals") it would appear that Mars's desert "oases" are situated in valleys, and probably mark the sites of desert water supplies, as well as the sites of present centers of population; in other words, cities and towns and their surroundings, to which the produce of the crops raised in the extensive blue-green areas of Mars is conveyed by some method of transport running along the "canals" which serve them, and that the square, lighter-colored areas mainly situated at "double canal" crossings are relatively small patches of cultivation situated on an intervening height.

The spots ("oases") in the extensive blue-green areas, on the other hand, probably mark points at which water is collected, and thus differ to some extent in character from the dark "oases."

The rise from the center of an extensive depressed blue-green area to the raised central desert is probably negotiated through a valley leading therefrom, as shown in the sketch above (Fig. 1). Such markings on Mars are designated by Mr. Lowell as its "carets."

A possible solution of the flow of water from Mars's polar caps is thus arrived at. In its first rush from the melting caps the water is carried forward by gravitation and comes to rest at low-lying points on the planet, to be then pumped up to high-level service reservoirs through the Martian "canals," which thus correspond to what on earth are known as "rising mains."

From these service reservoirs the water is mainly distributed to the lands to be irrigated by gravitation through pipes under static pressure, but may be also, in some cases, perhaps, distributed through open channels.

WATER FROM POLAR CAPS INSUFFICIENT.

The extensive blue-green areas of Mars cover about 21,000,000 square miles of its surface. The south polar cap when at its maximum covers about 10,500,000 square miles; therefore half a foot of water on the latter area would suffice to cover only the blue-green areas to a depth of 3 inches.

The north polar cap has a maximum area of 7,000,000 square miles, and the water available from it could only cover all Mars's blue-green areas to a depth of $\frac{7}{10} \times 3 = 2$ inches, supposing always that it can be fully utilized.

Such light coverings would be quite inadequate for the maintenance of vegetation, and a farther supply for the half-yearly irrigation of Mars's blue-green areas is clearly needed. On the assumption that a 9-inch covering in six Martian months is the least which will, under the assumed conditions, suffice for the maintenance of vegetable life on Mars, the deficiencies to be made good would be thus 6 inches and 7 inches, respectively.

The assumed rate of flow from the south polar cap has been taken at 10,000,000 cusecs; this is sufficient to cover all Mars's blue-green areas to a depth of 3 inches in three Martian months, and would cover them to a depth of 6 inches in six Martian months. The quantity of water needed for a 9-inch covering in six months from Mars's assumed underground supplies would thus be a continuous flow of 15,000,000 cusecs when the south polar cap is not melting, and therefore 5,000,000 cusecs when it is melting.

Assuming then that a continuous flow of 15,000,000 cusecs will suffice for the full irrigation of all Mars's blue-green areas, we may proceed to try to ascertain the power which would be needed to effect this purpose when the water is pumped through pipes or conduits 6 feet in diameter at a rate of 90 cusecs per pipe or conduit.

POWER FOR PUMPS.

As we have seen, the average length of each "canal" from collecting reservoir to service reservoir would be probably, at most, about 1,400 miles, and we should therefore require ten pumping stations of 1,150 N.H.P. on each 6-foot diameter pipe. The power required for each pipe would be thus 1,150 × 10 = 11,150 N.H.P.; and as to deal with a continuous flow of 15,000,000 cusecs the total number of pipes needed would be 170,000, the total power required to work the entire system would be 170,000 × 11,500 = say 2,000,000,000 N.H.P. Something would have to be added for the "canals" needed to help a portion of the water set free from both the melting polar caps from their vicinity, and we may therefore put the sum total of the power which would have to be developed at 2,500,000,000 N.H.P. This is only about four thousand times as much as that under development at the Niagara Falls alone, which is 650,000 horse-power, and much under that in daily use on our own earth, and therefore not beyond development.

In western Australia 5,600,000 gallons of water are daily pumped at a rate of 10 cusecs through a 30-inch steel pipe and over a rise of 1,200 feet from a reservoir at Perth to the mining center of Coolgardie, 351½ miles distant therefrom. Coolgardie is situated on a tableland which is one of the driest places on earth, the maximum temperatures recorded in its neighborhood being 132 deg. Fahr in the shade and 157 deg. Fahr. in the sun. The distance from the storage reservoir at Perth to the service reservoir at the top of the intervening rise of 1,200 feet, from where the water gravitates under static pressure 43½ miles to Coolgardie, is 308 miles, and there are eight pumping stations in this distance, their average distance apart being thus 38½ miles. The average horse-power likely to be needed at each pumping station works out to 330 N.H.P.

With eight pumping engines of this power, 5,000,000 gallons of water could on Mars be daily forced up a height of 1,200 feet through a similar 30-inch pipe line having a total length of about 680 miles, or more than twice the distance from Perth to the service reservoir.

Unless water is obtainable from the interior of Mars, its polar caps and shallow swamps (the latter are to be found there) would alike soon cease to exist, and the planet roll through space a dead and dried-up world, which at present is certainly not the case.

Evaporation from the water so obtained and used in the irrigation of all the blue-green areas would supply the water vapor known to be present in the Martian air, a portion of which vapor, when carried by the Martian winds to the planet's polar regions, is there deposited, owing to the intense cold there met with, mainly in the form of ice spicules, to later on melt and be again used for irrigation.

A considerable portion of the water used for the full irrigation of the blue-green areas would filter back to the underground supplies from where it was obtained and replenish them; there would thus be only a partial annual drain on these supplies.

For natural vegetable growth dependent on rainfall (assuming such a fall), a much larger supply of water than a 9-inch covering in six Martian months would not only be needed, but a large portion of the rain falling on the surface of Mars would be wasted by falling at the wrong time and also by falling on deserts where it would be of no use. The least amount which would probably suffice would be a 24-inch fall in six Martian months.

Melting Points of Refractory Oxides

The melting points of some refractory oxides have been determined by the Bureau of Standards in a graphite resistance vacuum furnace. The temperatures were measured by an optical pyrometer and heating curves were plotted. The production of smoke from some oxides was found to be a source of error, as the smoke interferes with the use of the pyrometer. These valuable experiments are described by the investigator, Mr. C. W. Kanolt, in Vol. 10, No. 2 of the *Bulletin* of the Bureau.

The Building Fund of the Royal Geographical Society has received a contribution of $5,000 from the government of Australia.

Result of First Contest for Safety in Aeroplanes, in France

Remarkable Performance of the Sperry Gyroscopic Stabilizer

A YEAR ago we announced an international competition for the development of a safe aeroplane. Over $100,000 in prize money was to be awarded, there being a Grand Prix of $80,000 for the safest aeroplane or device applicable to an aeroplane to make it safe. Great latitude was given inventors and no strict rules regarding the judging of the machines and devices were drawn up. Consequently it was a very difficult matter for the judges to decide what constituted the greatest advance in the line of safety. They decided not to award the Grand Prix, but to hold it for a second competition. There were fifty-six entries accepted and twenty-one competitors appeared. But two prizes were awarded, although seven contestants were given sums ranging from $1,000 down to $200 to encourage them. The total sum distributed was $28,200, as follows:

$10,000 to the Sperry gyroscopic stabilizer.
6,000 to the Paul Schmitt biplane with variable incidence planes.
3,000 to the Caudron biplane.
2,000 to the Doutre stabilizer, a pressure plate device.
2,000 to the Avisto carburetor.
1,000 to the Etevé stabilizer.
1,000 to the Moreau aeroplane (automatic stability by pendulum seat).
400 to the Robert safety parachute.
200 to the Philippe and Perron starter.

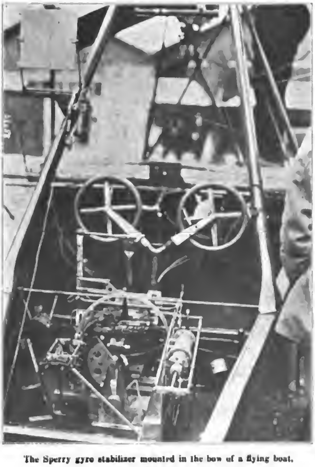
The Sperry stabilizer was fully described in the SCIENTIFIC AMERICAN of June 7th, 1913, and August 8th, 1914. The tests made before the judges on a Curtiss aeroplane by Lawrence Sperry and his mechanic demonstrated that the machine was always held on a level keel, even when the mechanic walked well out toward the ends of the planes at a time when the pilot was standing and holding his hands above his head. The device maintains both the longitudinal and transverse stability and if the aeroplane drops below a certain speed it volplanes automatically. Manual control can supplant automatic at any moment the pilot wishes. Four small gyroscopes (two pairs) are used to control valves regulating the operation of the ailerons and elevator, which is accomplished by means of compressed air. The whole apparatus weighs but 40½ pounds. There were a number of difficulties in applying the gyroscope to the aeroplane for this purpose. These were successfully overcome by Mr. Elmer A. Sperry, the inventor, who is the first to so apply the gyroscope that no matter in which direction an aeroplane tends to tip, it will be kept from tipping by proper instantaneous setting of the controls.

A full description of the Paul Schmitt biplane was published in the SCIENTIFIC AMERICAN of July 18th. The variable incidence of the planes of this machine in flight make it possible to carry big loads and to prevent stalling, as the machine is controlled by changing the angle of the wings rather than by means of the regular control surfaces. This biplane has made some extraordinary speed and height records carrying five or six passengers. It broke twenty-seven world's records in one day and made eleven new ones. It is able to start and alight in a space of 300 feet.

It is probable that had there not been so much red tape in accepting entries, A. Leo Stevens would have won a substantial prize with his safety pack—a parachute device that is worn like a knapsack. Mr. Stevens, who is a member of the Aero Club of France, cabled his entry and entrance fee, but the entry was thrown out on the pretext that the money was not received in time. This action of the Union has deprived the French government of a valuable apparatus for saving the lives of its aviators. Red tape in our War Department is similarly affecting our aviators, although the Sperry stabilizer is being fitted to several naval aeroplanes.

In the August issue of *Aircraft* we find the following interesting story of the French trials:

> The Sperry gyroscope, in its application to the flying machine, is another example of the remarkable speed of the development of some modern epochal invention. Two years ago, Mr. Elmer A. Sperry fitted a Curtiss aeroplane with his device, and experiments in stabilizing were then undertaken. Careful testing continued all winter at San Diego, under the eye of Glenn H. Curtiss and the officers of the Aviation Corps of the United States Army. Many improvements were made, and the progress was steadily continued for many months at Hammondsport.
>
> Full details have now been received of the signal triumph of this wonderful product of American ingenuity in France, where, at a safety contest the award of $10,000 offered by the French War Department was won by the aeroplane fitted with the Sperry stabilizer. The contest, extending over two hours, was held on the Seine between Bezons and Argentine. Lawrence D. Sperry, son of the inventor, piloted the winning machine, assisted by a mechanician. The control of the machine was perfect, young Sperry standing up during the flight with his arms folded, while the mechanician climbed to the end of the lower plane and back.
>
> M. Rene Quinton, the president of the National Aerial League of France, who states that the invention is being hailed by European experts as one of the most important contributions ever made to the science of aviation, gives a graphic account of a flight which he took with young Sperry. He says: "Imagine the aeroplane in flight. At a given moment the passenger rises, leaves his seat, and climbing out onto a wing calmly walks here and there, as the fancy takes him. At the same time, the pilot rises and holds his two arms above his head, in order to prove that he is not touching any of the mechanism. The aeroplane, abandoned and apparently thrown out of equilibrium, keeps on its even way at a speed of 50 miles an hour. We were in the very teeth of the heavy wind, but, strange to say, it had no effect upon the working of the apparatus. There was no rolling, no pitching. One might have thought oneself in an ordinary machine in absolutely calm weather. At a height of 150 meters, Mr. Sperry made two demonstrations of automatic volplaning. It is well known that in order to execute a volplane, the aviator must allow his aeroplane to dive abruptly so as to regain the speed that the stopping of the motor has caused him to lose. Would the Sperry apparatus be able to accomplish this difficult maneuver without the aid of man? In order to prove to me that it would, Mr. Sperry stopped his motor, then raised his hands once more to show that he was not touching the levers. Nothing happened for five or six seconds; the machine appeared to have stopped. Then, suddenly it plunged head down, like a dolphin, in a dive that was as graceful as it was impressive. We rose again, and Mr. Sperry had a new experience for me—a glide with one wing so sharply inclined that it seemed incredible that the apparatus could be working. We leaned over toward the horizon at an angle of 45 degrees. The pilot did not touch the controls. The machine governed itself, and even in this abnormal position, while literally buffeted by the wind, it navigated in absolute safety. The Sperry apparatus consists of four little gyroscopes that never fail to bring back the machine to a horizontal plane. The entire outfit weighs about forty pounds. The tests I have described indicate remarkable progress toward the solution of one of the most wonderful problems of the age, that of safe human flight. They prove that we now have the means of enabling the aeroplane to control itself, whether it is rising, flying straight ahead, descending or battling with the wind, and that this marvelous machine, hitherto restricted to the few, is soon to be made available to the whole human race; the peer in speed of the rapidest automobile, and absolutely as easy and as safe to operate."
>
> The Sperry machine is small and compact, 14 inches high by 11 inches wide, and it can be applied to any aeroplane without change in design. In the appended illustration the complete apparatus is shown, mounted on the bow of a flying-boat, the spray hood having been removed for the purpose of taking the picture. The gyroscopic element is plainly shown under the light semi-circular bow which actuates the longitudinal servo-motor, the lateral servo-motor being seen just behind the top of the bow. The anemometer which actuates the automatic volplane mechanism is seen on the upper left.
>
> For the additional guidance of the observers attending the French demonstration, a special programme was given out, which is most suggestive as indicating the thoroughness of the tests prepared. The programme sets forth:
>
> In demonstrating the Sperry-Curtiss stabilizer the pilot will carry out this programme as far as possible.
>
> (A) An explanation of the aeroplane used and the method of operation of the apparatus.
>
> You are asked to especially observe the following:
>
> 1. The aeroplane used is the well-known Curtiss flying boat with the controls arranged on the usual Curtiss system operated solely by hands and shoulders. The feet are not used in any way in controlling the machine. The aeroplane has the normal Curtiss relation between the gravity, thrusts and buoyancy centers, and has no inherent stability.
>
> 2. The servo-motors of the automatic stabilizer are directly connected with the same controls that the aviator would ordinarily operate by hand.
>
> 3. A simple foot treadle can instantly throw both the lateral and the longitudinal controls into or out of operation at will. When the automatic control is thrown into operation, it moves the controls when there is any relative movement between the aeroplane and the gyroscopic base-line. This will be demonstrated by moving the gyroscopic base-line, the gyros being stopped in this case. When the machine is in flight, the rotation of the gyros holds the structure in which they are mounted truly horizontal regardless of all movements of the machine.
>
> 4. When the automatic stabilizer is in operation, the controls are held with perfect rigidity, and the pilot cannot use them even if he wishes.
>
> 5. When the automatic stabilizer is in operation, the pilot uses the small lever to the left for controlling the aeroplane longitudinally, and the small pendant lever on the steering wheel for controlling the aeroplane laterally. He is entirely relieved of the task of stabilizing the aeroplane, and uses these levers only for directing its flight.
>
> (B) Demonstration of the action of the automatic stabilizer when an upsetting force is applied in flight.
>
> 6. The passenger making this flight weighs about eighty kilogrammes.



The Sperry gyro stabilizer mounted in the bow of a flying boat.

7. The machine will rise from the water in the usual manner, and fly under automatic control.

8. Automatic lateral control will first be demonstrated, as follows: The passenger will leave his seat and climb out on the wing to one side for a distance of between one and one half and two meters from the center of gravity of the plane. While this is being done the machine will be under automatic control.

Observe that:

(a) The upsetting couple applied by the passenger is between one hundred and twenty and one hundred and fifty meter kilogrammes.

(b) The pilot is showing that the machine is under automatic control by moving out of his controlling seat and holding his hands above his head.

(c) The aeroplane is held perfectly level by the operation of the automatic control.

(d) As the passenger moves out on the plane, the angle at which the ailerons meet with the air gradually increases to automatically compensate for the upsetting couple. As the passenger returns toward the center, the ailerons gradually return to their normal position.

9. Demonstration of automatic longitudinal control. The passenger will leave his seat, climb up on the lower plane, and go backward, approaching the propeller as closely as possible.

The upsetting couple applied in this case is about eighty meter kilogrammes.

The same points should be observed as given under No. 8, i. e., that the machine is entirely under automatic control, that the longitudinal inclination of the aeroplane does not change, and that the rudder is now compensating for the upsetting couple.

(C) Demonstration to observers who will make flights as passengers in the demonstrating machine.

The passenger is asked especially to observe the following points:

10. After gaining speed on the water, the automatic stabilizer will be thrown in, and the aeroplane will rise from the water under complete automatic control. In rising from the water, and in controlling the angle or climb of the aeroplane, the pilot uses the small lever to the left.

11. The aeroplane flies smoothly with almost complete absence of the so-called "bumps."

12. The pilot is relieved from all work of stabilizing the machine, and has only to direct its flight, which task becomes simpler and easier than steering a motor car. The pilot will from time to time place his hands on the steering wheel for the purpose of keeping the machine on a straight course of flight. When the pilot touches the steering wheel while the automatic stabilizer is in operation, he cannot in any way assist the apparatus in stabilizing the machine, because the controls are rigidly held by the servo-motors.

13. The gyroscopic base-line, i. e., the structure in which the gyroscopes are held, constantly maintains the horizontal plane. The graduated circles on this device act as an accurate clinometer, constantly indicating the inclination of the machine laterally and longitudinally.

14. The gyroscopic base-line is causing the controls to ailerons and rudders to make very small movements. These movements are instantly counteracting each disturbing effect simultaneously with its occurrence.

15. By operating the foot-treadle the pilot can instantly throw out the automatic control and assume hand control. Note the difference in regard to smoothness of flight when the automatic control is thrown out.

16. When the pilot throttles his engine, and in that way approaches too closely the critical speed necessary in order to sustain the aeroplane, the automatic air velocity device operates to volplane the machine to an angle of about twenty degrees.

17. When the automatic air velocity device has volplaned the machine, the pilot cannot regain automatic longitudinal control until the volplane has brought the speed of the machine back to normal.

18. When the aeroplane turns, automatic control continues to operate, although the pilot can use any angle of banking he wishes.

19. When the speed of the engine is reduced, all parts function as before. The automatic stabilizing device is independent of the engine for a time sufficient to enable the pilot to make a landing or to restart the engine in case the latter accidentally stops.

20. The pilot alights on the water with the aeroplane under full automatic control.

Recording Moonlight and Night Cloudiness

By Alexander McAdie

One looks in vain through text-books on meteorology, official circulars of instruction, observers' handbooks, etc., for information regarding records of moonlight and night cloudiness. In fact, cloudiness during the dark hours, or practically half of the time, is discreetly let alone by professional meteorologists. If recorded at all, the data are in abbreviated form, and are generally based upon hearsay, such as statements of night watchmen, milkmen, and others. Such data are, of course, of doubtful value. And yet many a case in criminal and civil courts requires evidence of a positive character regarding cloudiness at night, and particularly the illumination due to moonlight.

For getting a record of night cloudiness, there has been used at Blue Hill Observatory for many years a Pole-star recorder. This is a photographic record of a star trail, in this case Ursa Minor, devised in 1885 by Prof. E. C. Pickering. In 1901 the instrument was modified by Ferguson, and a record for two weeks may be obtained on one film; the instrument is practically automatic. The cost is not large, and there would seem to be no good reason why the instrument should not be generally used. If the night is clear, in the northern portion of the sky, the trail made by the star is continuous. For example, in Fig. 1 the record for the night of April 22nd-23rd shows that the sky was entirely clear, whereas the record for April 23rd-24th shows cloudiness at intervals during the early portion of the night, complete cloudiness for an hour at midnight, and clear weather thereafter. Similarly, the night of April 24th-25th was more or less cloudy. In this latitude the instrument gives a fair record of night cloudiness for the entire sky.

For recording cloudiness during the day hours various sunshine instruments are used, some thermometric (therefore responsive to heat, and recording too much if the temperature continues high after sunset, and too little if the temperature falls rapidly during the day); and the photometric based chiefly on the discoloration of some sensitized paper. At Blue Hill there has been in constant use the well-known Campbell-Stokes sunshine recorder, which consists essentially of a glass sphere focusing the sun's rays and burning a record upon a strip of prepared paper. It occurred to the writer that this instrument might also be used to obtain a record of moonlight by placing a strip of photographic paper, not over-sensitive, in the metallic frame, protecting it as much as possible from extraneous light and from the weather. Some very good records have been thus obtained, and it is quite easy to thus ascertain the intensity of the illumination due to the moon. An interesting record (Fig. 2) is that of March 11th-12th, during a lunar eclipse. The moon entered the penumbra at 8:11 P. M. and entered the shadow at 9:42. The middle of the eclipse was at 11:13 P. M., the moon leaving the shadow at 12:41 A. M. and the penumbra at 1:45 A. M. The night was beautifully clear. On the record (Fig. 2) it will be seen that the light gradually became dim, disappearing about 11 and reappearing after midnight. A record (Fig. 3) for the succeeding night shows that there was moonlight, with intervals of cloudiness, until 10:50 P. M., after which the moon was obscured. It is not known that any previous records of this character have been made.

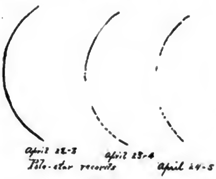


Fig. 1.

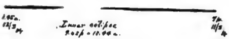


Fig. 2.

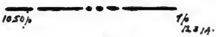


Fig. 3.

The whole subject of cloudiness, or perhaps it would be better to say obscuration by clouds, is in a most unsatisfactory state. At most observatories it is considered sufficient to enter the state of the sky twice in twenty-four hours. In this country the hours are 8 A. M. and 8 P. M., but such a practice certainly does not afford a fair basis for estimating the relative cloudiness of the place. On the other hand, a systematic survey of the cloud forms requires endless time and patience. One of the most remarkable cloud records is that of Mr. Spencer C. Russell at Epsom, Surrey, who maintained an hourly record for eight years. During this period he accumulated nearly 100,000 individual records. He has published the results of monthly and hourly cloud-form frequencies in the *Quarterly Journal* of the Royal Meteorological Society, October, 1913. He groups the clouds into four main classes: 1, Upper clouds, including all cirrus type; 2, intermediate clouds, including most of the cumulus and stratus formations; 3, lower clouds, including fog; and 4, diurnal ascending current formations. Curves showing hourly and monthly frequencies are given at some length. Nor is the matter of cloudless periods omitted, as is so often done in cloud discussions. One remarkable period of cloudlessness is reported as occurring in 1908, when from 6 P. M. April 4th until 5 P. M. April 11th—167 hours—no clouds were visible. The duration of cloudlessness varies greatly with locality. On the Atlantic seaboard periods exceeding three days are rare; but in the far western part of the United States, especially in California and Arizona, periods of a month or longer without cloudiness are not infrequent. Langley in his experiments at Mount Whitney speaks of the weeks which passed without a cloud in the sky; and it is common experience in the high Sierras during July, August, and September to find the sky entirely cloudless, week after week. On the other hand, in certain seasons thunderstorms may be frequent and afternoon cloudiness marked. The writer once had the privilege of spending a week on the summit of Mount Whitney at the end of August, and more than half the time it was cloudy.

While it is important, for many reasons, that cloudiness should be reported with some detail, still the records should be as compact as possible. A good illustration of a handy form of record is shown in Fig. 4. This was made at San Francisco some years ago, under the writer's direction, for a lighting company. A similar record for the succeeding month showed an entirely different distribution of cloudiness; in fact, the month was so cloudy that the demand for light was double that of the preceding month. At Blue Hill we have adopted a method of charting the cloudiness for each hour throughout the year on a sheet of millimeter paper 24 centimeters wide and 73 centimeters long. The record of cloudiness at Blue Hill is probably more complete than at any other point in the United States.

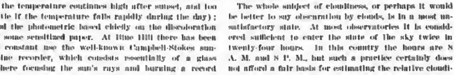


Fig. 4.—Record of cloudiness covering one month.

Determination of Ammonia in Illuminating Gas

Four common forms of apparatus for the determination of ammonia in gas, and a new form designed on the principle of the Cumming wash bottle were recently tested at the Bureau of Standards, at Washington, by J. D. Edwards, laboratory assistant, and the results show that the amount of ammonia in a gas can be determined with sufficient accuracy for official or commercial testing with any of the five forms. The advantages and disadvantages of each form as well as precautions to be observed in operations are pointed out in the text.

The subject is fully treated and described, with illustrations, in No. 34 of the technological papers published by the Bureau of Standards, and in summing up it is recommended that the ammonia be determined by absorption in sulphuric acid with subsequent titration of the excess acid and not by passing gas through the apparatus until a color change is shown by the indicator. It is satisfactory, however, when it is only desired to know whether the ammonia content is above or below a certain limit, to pass a predetermined volume of gas and note whether the acid has been completely neutralized or not.

Sodium alizarinsulphonate, cochineal, and paranitrophenol have been found to be satisfactory indicators. The use of a N/50 solution of sulphuric acid as an absorbing agent is recommended, although the strength may be varied to meet different conditions.

The errors due to incomplete washing and the use of glass beads are discussed, and means of eliminating their effect are given. See B. of S. Circular No. 48.

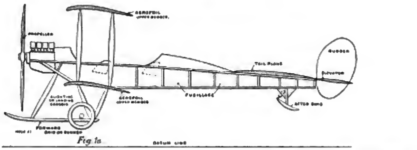
The Flying Machine from an Engineering Standpoint—II*

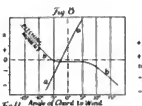
A Review of Recent Progress

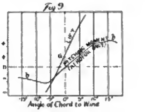
By Frederick William Lanchester, M. Inst., C. E.

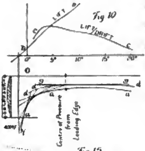
Continued from Scientific American Supplement No. 2014, Page 91, August 8, 1914

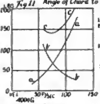
Referring to Fig. 7a, it may be observed that the character of the pitching-moment curve depends primarily upon the form of the aerofoil, the position of the center of gravity, and the effective area of the tail-member. By altering the angle of the tail-plane (or by altering its effective angle by moving the flap known as the elevator) the datum line of Fig. 7a is in effect raised or lowered, but the form of the curve itself is not materially changed. It is evident, therefore, that a given machine may be catastrophically stable within certain limits of the adjustment of its elevator; that is to say, referring to Fig. 7a, it will be seen that the datum line may either cut the curve once or three times; the range of adjustment of the elevator that results in cutting the curve once leaves the machine catastrophically stable; but when the elevator is adjusted so that the datum line cuts the curve three times the machine is catastrophically unstable. In such a case as that shown by the dotted datum line in Fig. 7a, in which the machine is catastrophically stable, the form of the pitching-moment curve is still open to objection. Not only is it always possible for the pilot to bring about catastrophic instability by an otherwise well-intentioned movement of his elevator, but the restoring couple for pitching beyond a small amplitude ceases to follow even approximately the straight-line law, a fact that inevitably imperils the flight-path stability. Even when, as illustrated in Fig. 8, the pitching-moment curve *bb* never passes the horizontal, and so catastrophic instability is no longer to be feared, the conditions are not satisfactory, since there may be a considerable change of attitude of the machine without giving rise to any commensurate restoring couple.

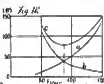


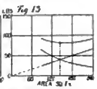


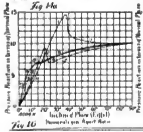


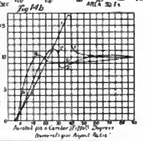


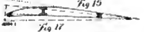


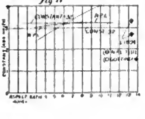


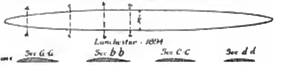












The undesirable kink in the pitching-moment curve, shown in Figs. 7a, 7b, and 8, is due to the movements of the center of pressure of the aerofoil itself in relation to the position of the center of gravity. The tail plane alone will give a pitching-moment curve of the type illustrated in Fig. 6, but the fore-and-aft change of position of the center of pressure of the aerofoil, at different angles of attack, gives rise to a pitching-moment curve whose exact character depends upon the position of the center of gravity. Should this correspond to a positively loaded tail, a curve of the type *bb*, Fig. 9, will result; this, superposed on the tail component, imparts to the pitching-moment curve of the complete machine the kink shown in Fig. 7a.

In order definitely to make sure of a satisfactory pitching-moment curve for the complete machine, the pitching-moment curve of the aerofoil alone should at no point exhibit an inverse trend. To achieve this it is necessary to bring the center of gravity appreciably in front of the most forward position of the center of pressure of the aerofoil, so that the tail-plane will under all conditions carry a slight negative load. Taking it as a basis that at the worst point the pitching-moment curve for the aerofoil alone shall be horizontal (the form of curve shown in Fig. 8), the geometrical construction given in Fig. 10 may be employed to give a suitable location to the center of gravity; here the locus of the center of pressure (as experimentally determined) is given by the line *aaa*, the pressure-reaction curve is shown by the line *bbb*, the dynamic zero being on the line *OY*. A number of tangents to the pitching-moment curve are drawn at random from points on the axis *OY*, and are produced a distance equal to their own length beyond the point of contact, the extremities of these tangents defining a curve *ddd*. Draw *gg* tangent to *ddd*, then the center of gravity should be situated on, or forward of, the line *gg*. The location of the center of gravity on this line gives a pitching-moment curve for the aerofoil alone, whose point of inflection is horizontal (as in Fig. 8). If we assume the machine flown at a normal speed corresponding to the maximum lift/drift ratio of the aerofoil (curve *cc*), the center of gravity in this particular case is one eighth of the chord length in advance of the center of pressure. Assuming the tail length equal to three times the chord (as in the "B.E. 2" type of the Royal Air-Craft Factory, whose outline elevation forms Fig. 1a) this is equivalent to a negative load on the tail equal to 0.04 (4 per cent) of the weight of the machine.[9] A machine so ballasted may be regarded as absolutely secure from catastrophic instability, and as having a pitching-moment curve of an adequate character.

In connection with the present subject it is worthy of remark that in a well-designed aerofoil the most forward position of the center of pressure is never far removed from the point of maximum lift/drift ratio;[10] this fact is of importance, inasmuch as it permits a considerable range of movement round about the attitude of normal flight without introducing grave irregularities in the pitching-moment curve. Were it not for this the required conditions might frequently be far more difficult of fulfilment than is actually the case.

8. *The Laws of Resistance.*—Having established the general character of the airway, or track on which the flying machine is sustained, we pass directly to the consideration of the law of resistance, as determining the coefficient of traction, on which depends the power expenditure. It is customary, and it is correct, to regard the resistance encountered by a machine in flight as made up of two parts: first, the direct resistance, which varies approximately[11] as V^2, namely, that form of resistance common to flying machines, dirigibles, motorcars, ships, etc.; in other words, the ordinary resistance experienced by any vessel or body in its passage through a fluid; and, secondly, the flight resistance proper, which follows an entirely different *régime*.

So far as the pilot or aviator himself is concerned, all the direct resistances may be regarded as of the same kind and grouped together, namely, the sum of the eddy-making and skin-frictional resistances due to the fuselage, the alighting châssis, and the various struts, stays, and spars, whether belonging to the body of the machine or aerofoil; also the engine resistance (if exposed), the radiator, and the frictionally exposed surfaces of the rudders, fins (vertical surface), and of the aerofoil itself. Resistance from all these causes varies approximately as V^2, and so can be represented by an equivalent normal plane, and this equivalent normal plane is one of the resistance constants of any given machine; it may be represented by a graph *aa*, Fig. 11—a portion of a parabola—covering the range of speed of which the machine is capable.

From the point of view of the pilot, the aerodynamic resistance *bb*, which goes to make up the total *cc* (Fig. 11), follows, within limits, the inverse square law, mately, varies as k/V^2, where k is a constant determined by the design of the aerofoil; there is a critical angle which defines the low velocity limit of this law, and at best the inverse square law is but an approximation; it is the correct law to assume for an undefined form of aerofoil, but every individual design has its own particular manner of variation, which must be ascertained by experiment. The experimental determinations for any aerofoil include, with the aerodynamic resistance, the skin-frictional, and a certain amount of other inseparable direct resistance, so that if experimental values are taken, these resistances should not be again included in the computation of the equivalent normal plane.

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* The James Forrest lecture, delivered before the Institution of Civil Engineers on May 5th. Compare also the same author's paper on "Catastrophic Instability in Aeroplanes," Scientific American Supplement, February 14th, 1914, p. 98.

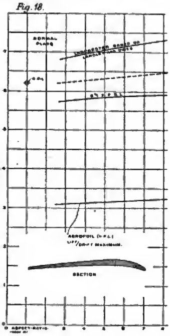
[9] A similar conclusion was reached by the author some eight years ago, based on an entirely different method of investigation. For model experiment a negatively loaded tail was found to be advantageous; the figure 0.035 is given in "Aerial Flight," vol. ii, p. 335. It is desirable to work with a less proportion of negative load from the point of view of keeping the resistance low; evidently the matter is one for compromise.

[10] This is not in the nature of a coincidence; a well-designed aerofoil at its attitude of least resistance meets and leaves the stream lines representing the relative air flow (in the region of its mid-section) conformably. Under these conditions small changes of attitude one way or the other do not cause any abrupt change in the aerodynamic system. Such expedients as flattening the extremities and giving a reflex curve to the trailing edge are also found to be of service.

[11] The V^2 law, it would appear, in no case exactly represents the actual facts; the departures from this law crop up in various and sometimes most unexpected directions. In the case of resistance due to skin friction, sufficient data exist to enable the degree of departure from the law to be computed; in other cases, as for example, in the pressure reaction experienced by an inclined plane or aerofoil, departures of a different kind have been demonstrated, and are being gradually elucidated by experimental investigation. In spite of these shortcomings, the foundation theory of flight is to-day, and probably will continue to be, based on the V^2 law.

From the point of view of the designer, things wear a somewhat different aspect, and a sharp line has to be drawn between two different classes of direct resistance. In the first place, there is the body resistance, which is taken to include the resistance of all those parts, such as fuselage, alighting gear, etc., which is independent of the design of the aerofoil. In the second place, there is the direct aerofoil resistance, including the skin-friction and strut and stay resistances, which are variables depending upon the area and span, and otherwise upon the design of the aerofoil itself. The designer can, by sufficiently extending the aerofoil, reduce the aerodynamic resistance (as shown by Langley) to as low a value as he please, within the limit prescribed by the question of the added weight; but this reduction in the aerodynamic resistance is accompanied by an increase of skin-frictional and other direct aerofoil resistances, so that for any given machine and designed velocity there is an extent of aerofoil beyond which it does not pay to go; there is definitely a design of least resistance.

Fig. 18.



I have shown that, treating the matter from the broad standpoint of general theory, the condition of least resistance is reached when the aerodynamic and direct resistance of the aerofoil are equal to one another.[19] This is illustrated by Fig. 12, in which (as in Fig. 11) *aa* represents the graph of the direct resistance ($R \propto V^2$), and *bb* that of aerodynamic resistance ($R \propto 1/V^2$), and *cc* is the total (ordinates = resistance, abscissæ = velocity). In Fig. 13 a similar result is shown in which the plotting is given for constant velocity (abscissæ = area), as representing more literally the problem as presented to the designer.

TABLE IV.—*Values of β (Angle of Trail) for Least Resistance.*

Aspect Ratio.	$\xi = 0.020$.	$\xi = 0.015$.	$\xi = 0.010$.
	deg.	deg.	deg.
3	0.189 = 10.8	0.163 = 9.3	0.133 = 7.6
4	0.196 = 11.2	0.169 = 9.7	0.138 = 7.9
5	0.202 = 11.6	0.174 = 10.0	0.142 = 8.1
6	0.206 = 11.8	0.178 = 10.2	0.145 = 8.3
7	0.212 = 12.15	0.183 = 10.5	0.149 = 8.5
8	0.218 = 12.5	0.189 = 10.8	0.155 = 8.8

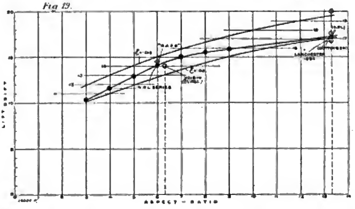
The general theory on which the foregoing result is based depends upon and is subject to the limitations of the $1/V^2$ law of aerodynamic resistance. This law corresponds to the straight-line law as correlating pressure and angle, and is a close approximation between useful limits, but breaks down at a certain critical maximum angle (depending mainly upon the aspect ratio), as shown in the examples given in Figs. 14a and 14b. The square plane follows a straight-line law up to about 30 degrees, in the plane of aspect ratio = 6; the limit is about 12 degrees, the breakdown of the law at these limiting angles puts a very definite limit to flying at low speed.

TABLE V.—*Pterygoid Aerofoil.*

Load (pounds) per Square Foot for Least Resistance.

	Flight Velocity. Feet per Second.	Values of Aspect Ratio. 3	4	5	6	7	8
$\xi = 0.020$	5	0.017	0.018	0.020	0.022	0.023	0.025
	10	0.068	0.075	0.082	0.089	0.094	0.101
	15	0.152	0.169	0.186	0.200	0.213	0.228
	20	0.270	0.301	0.330	0.355	0.379	0.405
	25	0.390	0.433	0.475	0.511	0.545	0.582
	30	0.610	0.676	0.743	0.800	0.852	0.911
	35	0.830	0.920	1.01	1.08	1.16	1.24
	40	1.08	1.20	1.32	1.43	1.51	1.62
	50	1.69	1.88	2.06	2.23	2.37	2.53
	60	2.44	2.70	2.97	3.20	3.40	3.64
	70	3.32	3.68	4.05	4.35	4.64	4.96
	80	4.33	4.81	5.30	5.70	6.07	6.47
$\xi = 0.010$	5	0.012	0.013	0.014	0.015	0.016	0.018
	10	0.047	0.053	0.058	0.063	0.066	0.071
	15	0.107	0.119	0.131	0.142	0.150	0.161
	20	0.190	0.211	0.234	0.253	0.267	0.287
	25	0.298	0.331	0.366	0.396	0.418	0.450
	30	0.427	0.475	0.526	0.570	0.601	0.645
	35	0.582	0.647	0.717	0.777	0.820	0.880
	40	0.760	0.845	0.935	1.01	1.07	1.15
	50	1.18	1.32	1.46	1.58	1.67	1.79
	60	1.71	1.90	2.10	2.28	2.39	2.58
	70	2.32	2.58	2.86	3.10	3.27	3.51
	80	3.04	3.38	3.73	4.05	4.27	4.59

Fig. 19.



I have demonstrated that the condition of least resistance implies, for an aerofoil of any given aspect ratio, a definite value of the angle of trail,[20] β, Fig. 15; the chord angle, except where a plane lamina is used, is an accidental quantity, and not, as frequently supposed, one of fundamental importance; calculated values of trail-angle β for least resistance are given in Table IV. Thus any aerofoil properly designed for least resistance for any given velocity of flight will be correctly designed for every other velocity provided that its load per unit area be varied as the square of the flight velocity.

It thus becomes possible to prepare tables of mean-pressure values proper to least resistance for different flight velocities and different values of aspect ratio (Table V). Tables IV and V are reproduced from my "Aerial Flight," vol. 1, pages 261, 262, and 271, the variable factors in addition to the flight speed being the aspect ratio, which is here shown as tabulated for values from 3 to 8, and the coefficient of skin friction, values of which are taken from 0.01 to 0.02 double-surface coefficient. These values for skin friction are on the high side, but as an actual fact the values given do fairly represent the total direct resistance that in practice depends upon the area of the foil, and which requires to be included in the useful application of the theory; the higher values, generally speaking, represent more closely biplane conditions, and the lower values are more applicable in the case of the monoplane.

It would appear from recent experiment that my conclusions, as given in Tables IV and V, though in the main correct, require revision; at least in a quantitative sense. Thus plotting values of the pressure constant, as derived from Table V, for different values of aspect ratio, and as determined for the condition of least resistance (maximum lift/drift) by the National Physical Laboratory, Fig. 17, we find the two in perfect agreement for aspect ratio = 6; we also find that both graphs slope in the same direction, namely, they give a higher pressure constant as appropriate to higher aspect ratio; we do not, however, find justification for the extent of the difference as given in my table; the National Physical Laboratory curve gives the effect as very slight indeed—in fact, almost negligible; the pressure constant for the aerofoil tested might be assumed as 0.32 for all values of aspect ratio without serious error.[21]

In Fig. 18, the National Physical Laboratory curve from Fig. 17 has been plotted for comparison with the curve of the normal plane. It is well known that the pressure constant of the normal plane is greater for planes of elongate form; the normal plane curves given in Fig. 18 are based on the determinations of Langley and Dines, as given in "Aerial Flight" (the upper curve); and the more recent determinations of Mr. Eiffel, the values according to this authority being very much lower. On the left, on the line aspect ratio = 1, we have the value for the square plane as determined by the National Physical Laboratory, and a curve is shown (dotted) directed toward this point as being the nearest we can at present do toward a representation of the truth.

The relation of the normal plane curve to the National Physical Laboratory curve aforesaid is most suggestive; it happens that the values of the constants are almost exactly in the relation of two to one; this is probably a mere coincidence; a more important fact is that the increase of the pressure constant of least resistance (touching changes of aspect ratio) for the aerofoil is almost exactly proportional to the ordinary pressure increase in the case of variations of proportion in the normal plane. This suggests that the increase in the two cases is due to the same primary cause; also that the coefficient of camber proper to least resistance is a quantity independent of the aspect ratio. If this should turn out to be the case, the reduction of the resistance for aerofoils of high aspect ratio may be regarded as due entirely to the fact that, where the cyclic component is stronger, the dip of the leading edge can be increased at the expense of that of the trail; that is to say, the chord angle may be diminished with higher aspect ratio, and with it the trail angle will be also diminished. This is contrary to the tabulated results of Table IV; if true, it must lead to the reconsideration of some of the assumptions on which I based my theory, or at least in the revision of some of the values of my constants.

In spite of the evidence, it is by no means certain that the matter is quite as simple as it appears. It is to be observed that any investigation to determine the effect of aspect ratio must of necessity involve a very complex experimental campaign, not merely a set of determinations with some half dozen or so models sawn off to length from a piece of Blériot or de Havilland "moulding"; this is exactly what was done in the experiments forming the basis of the plotting given in Fig. 17; any such method of investigation is liable to prove delusive.[19]

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[19] "Aerial Flight," vol. I, ch. vii.

[20] It is not easy to define the angle of trail of an aerofoil when the section is one of considerable body; clearly it is something intermediate between the upper and under surfaces, probably more nearly approximating to the former, as shown by the dotted line in Fig. 15.

[21] The series of observations from which the curve (*NPL*) in Fig. 17 was plotted are those given in Advisory Committee Report, 1911-12, Memorandum 69, § vi, Plate III; the section of the form of aerofoil used is given in the report, and is reproduced in silhouette in Fig. 18. The value of the pressure constant (at maximum lift/drift) evidently varies considerably for different forms of section. Rejecting forms that may be considered bad on account of their low maximum, we find: In Report 72 (1912-13) the fourth, fifth, and sixth sections given in Fig. 3, constants 0.322, 0.334, and 0.334, respectively. In the same report, § II, figures are given of the tests of four aerofoils varied as to bluntness of leading edge. The three best of these each had a constant approximately 0.4. In the same report an aerofoil corresponding in form to "R.A.F. 6" gave a value almost exactly 0.3.

In the first place each aspect ratio should be explored by a number of determinations using aerofoils of varying camber; secondly, the aerofoil section must not be uniform from end to end, the section must be "graded," or, as it is sometimes expressed, the camber must "wash out" at the extremities. Beyond this not one series must be tried, but some dozen or more. The final "winner" for each aspect ratio is the aerofoil of greatest lift/drift.

In my opinion, in the present unsatisfactory state of things, it is best (so far as the pressure constant is concerned) to assume a uniform value for all values of aspect ratio, say that given as appropriate to aspect ratio = 6 in Table V. Whether we consider the National Physical Laboratory result as valid or not, the salient fact is that we have at present no sufficient evidence that there is any change in the pressure constant worth taking into account. Alternatively, we are not going far astray if we assume aerofoil pressures equal to half the pressure on the normal plane, as shown in Fig. 18.

The most important fact with which we are immediately concerned in connection with the theory of least resistance is that the total aerofoil resistance for least value is almost constant in respect of velocity; in other words, provided that we design for least resistance, we know our traction coefficient in advance; it is virtually a constant, just as though the problem were that of an automobile required to ascend a hill of known gradient—an analogy which comprehends the fact that there is the direct wind resistance or body resistance additional in both cases. This constant is only within control inasmuch as by careful design the effective value of the coefficient of skin friction ξ can be kept down, and a high aspect ratio adopted. Theoretical values of least gliding angle (that is to say, resistance coefficient), tabulated for values of ξ and aspect ratio, are given in Table VI.[20] It is of some interest to inquire to what extent these results are in agreement with modern experiment.

TABLE VI.—*Least Gliding Angle* (= γ_1) (*Theoretical*).

n	$\xi = 0.025$.		$\xi = 0.02$.		$\xi = 0.015$.		$\xi = 0.010$.	
	deg.		deg.		deg.		deg.	
3	6.25	1 : 9.2	5.6	1 : 10.2	4.8	1 : 12.0	3.95	1 : 14.5
4	5.75	1 : 10.0	5.15	1 : 11.1	4.4	1 : 13.0	3.65	1 : 16.7
5	5.3	1 : 10.8	4.75	1 : 12.0	4.1	1 : 14.0	3.4	1 : 16.8
6	5.0	1 : 11.5	4.5	1 : 12.8	3.9	1 : 14.7	3.2	1 : 17.9
7	4.7	1 : 12.2	4.25	1 : 13.5	3.6	1 : 15.9	3.0	1 : 19.1
8	4.5	1 : 12.8	4.0	1 : 14.1	3.4	1 : 16.8	2.8	1 : 20.5
....	....	....	....	....	....	....	....	....
10	4.1	1 : 14.0	3.65	1 : 15.8	3.2	1 : 17.9	2.6	1 : 22
....	....	....	....	....	....	....	....	....
12	3.8	1 : 15.0	3.42	1 : 16.8	3.0	1 : 19.0	2.4	1 : 23.9

I have collected experimental data from various sources; a series of aerofoils of Blériot section,[21] aspect ratios vary from 3 to 8. Determinations of Voisin wing by Mr. Eiffel, aspect ratio 6.3. Aerofoil "R.A.F. 6" (Royal Aircraft Factory), aspect ratio 6. Aerofoils from my 1894 model, aspect ratio 13.3, Fig. 16, independent determinations by N.P.L. and Göttingen laboratories. The above are given in Table VII; columns 1, 2, and 3 give the aspect ratio, type, and authority respectively; column 4 gives the experimental determination, and my theoretical values are given in columns 5 and 6 for values of $\xi = 0.02$ and $\xi = 0.015$. Table VII is shown plotted in Fig. 19, the relation of aspect ratio to lift/drift being represented by curves drawn through the observed and calculated values.

TABLE VII.

1	2	3	4	5	6
Aspect Ratio.	Type	Determination by	Experimental	Calculated $\xi = 0.02$	Calculated $\xi = 0.015$.
3.0	Blériot section	N. P. L.	10.1	10.2	12.0
4.0	"	"	11.6	11.1	13.0
5.0	"	"	12.9	12.0	14.0
6.0	"	"	14.0	12.8	14.7
6.0	R. A. F. 6	"	14.8	....	
6.3	Voisin	Eiffel	14.0		
7.0	Blériot section	N. P. L.	15.1	13.5	15.9
8.0	"	"	15.5	14.1	16.8
10.0	.....	.....	....	15.8	17.9
12.0	.....	.....	....	16.8	19.0
13.3	Author 1894	N. P. L.*	17.1	....	....
		" *	17.6	....	....
		" †	20.0	....	....
		Göttingen‡	16.4	....	....
		" ‡	17.3	....	....

It will be noted on referring to Table VII and Fig. 19 that the agreement is almost complete. The two cases of the Eiffel determination of the Voisin aerofoil and the "R.A.F. 6" aerofoil are shown as outlying points, not being fully in agreement with the main run of the remaining experimental determination; it will be noted, however, that the whole of the experimental values lie between the two adjacent theoretical curves given, and the general form of the experimental curve corresponds to the curves given by my equations. It is true that there is something in the nature of the hump on the experimental curve, the extremities of which corresponds to a double-surface coefficient of skin friction of 0.02, whereas the central part of the curve round about aspect ratio = 6 rises nearly to the upper curve. This peculiarity of angular character of the curve may be a real feature, but I am disposed to think that it is more probably due to the fact that a great deal more experimental work has been done in the region of the hump of the curve, and so more highly perfected forms have been available than for aspect ratios of greater or less value. It would appear probable that if equal diligence were displayed in designing and testing forms of other aspect ratios, the upper theoretical curve ($\xi = 0.015$) would be found to be very close to the truth; some confirmation of this is found in the fact that the best value for the "R.A.F. 6" aerofoil, a form that has been subject to considerable study both by the Royal Aircraft Factory and the National Physical Laboratory, lies considerably above the curve representing the run of other observations.

In the National Physical Laboratory report to me on the tests of my 1894 model, it is stated that if it had been found possible to employ a velocity of 50 foot seconds instead of 30 foot-seconds, the figure obtained would probably have reached the neighborhood of 20. This value is also plotted as an outstanding point in Fig. 19.

Summarizing the position, it is clear that the tractive effort required to overcome flight resistance proper—namely, the aerofoil resistance—need not exceed 1 in 12 to 1 in 14, that is, 7 or 8 per cent, using an aspect ratio of about 6, and that values less than this are to-day actually reached in existing machines. It is, furthermore, apparent that if it is found practicable to employ really high aspect ratio, such as in my early flight models, there is every reason to suppose that a resistance coefficient as low as 6 per cent, or even 5 per cent, may prove to be attainable. This is the magnitude of the "constant gradient" of the motorcar analogy. We now pass to the consideration of body resistance.

(*To be continued.*)

Correspondence

[*The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.*]

The Use of Graphite in Steam Boilers

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

On page 35 of your SCIENTIFIC AMERICAN SUPPLEMENT No. 2011, dated July 18th, 1914, there appears an article, entitled "Graphite Against Furring," wherein it is intimated that the use of graphite in steam boilers as a scale remedy originated in Germany. We beg to inform you that the United States Graphite Company discovered this new use for graphite and were the first to offer it for sale for this purpose. The idea of using graphite as a boiler scale remedy was first brought to our attention by one of the best sugar plants operating in Colorado which experienced a great deal of trouble in this direction, and in casting about for a dependable removing agent secured, through our Denver branch, some of the graphite which we mine in Mexico, and tried it with such excellent result that we then, on our own account, made a great many exhaustive tests in a number of power plants, inclusive of our own here in Saginaw, where the feed water is usually bad.

The results following this investigation were so remarkable, and finding Mexican graphite to be, of all graphites, the best physically adapted for this use, we commenced to exploit it in that field with very remarkable success.

UNITED STATES GRAPHITE COMPANY.

Saginaw, Mich.

The Horsepower of a Cannon

A MODERN field gun firing a 15-pound shot with a muzzle velocity of 1,600 feet per second gives it an energy of $\frac{15}{2} + \frac{(1,600)_2}{32}$ foot pounds. If we assume that the time required is one hundredth of a second, the horsepower developed is

$$\frac{15}{2} \times \frac{(1,600)_2}{32} \times \frac{100}{33,000} =$$

$$\frac{15 \times 256,000,000}{2 \times 32 \times 5,500} = 108,000 \text{ h.p.}$$

Ships' guns greatly exceed this, the shot weighing as much as 1,100 pounds, and having a muzzle velocity of 3,000 feet per second. If we assume, as before, that the shot takes one hundredth of a second to reach the muzzle (it probably takes rather longer), we have for the horsepower in this case:

$$\frac{1,100 \times 9,000,000 \times 100}{2 \times 32 \times 5,500} = 28,000,000 \text{ h.p.}$$

We wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

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The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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[19] It is an old axiom that in conducting a scientific research only one condition (when possible) should be changed at a time. In trying to adhere to this rule too literally it is easy to mistake the shadow for the substance; in the present example, to vary the length of an aerofoil of constant section may appear superficially to be "changing one condition," but in reality it is nothing of the kind.

[20] From "Aerial Flight," vol. I, p. 262.

[21] Report of the Advisory Committee for Aeronautics, 1911-1912, p. 75.

* Velocity, 30 feet per second.

† Value at 50 feet per second (computed by National Physical Laboratory).

‡ Velocity not stated.

SCIENTIFIC AMERICAN SUPPLEMENT

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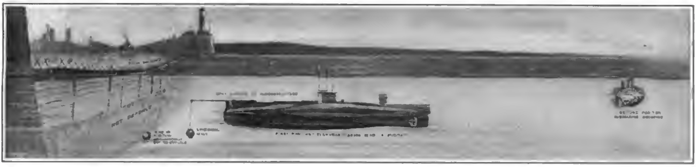
The decoys luring a battleship toward waiting submarines.

During recent manœuvers abroad two submarines, working in conjunction with two destroyers, formed a plan to "bag" an enemy. The destroyers went out as decoys to entice the enemy to follow them, and succeeded in getting a big cruiser to give chase. The course taken led to a convenient position from which the submarines could deliver a point-blank attack.



A submarine attack on a protected harbor.

Showing how a submarine, by means of a long spar lashed to its superstructure, was able to place a mine which completely destroyed a net and boom that was supposed to thoroughly protect a harbor from submarine attacks.

From "The Sphere."

Drawn by H. M. Davis.

Submarines confining dreadnoughts to harbor.

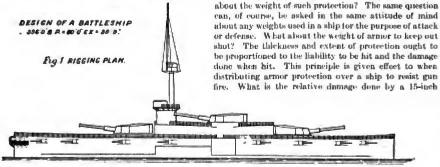
SUBMARINE AND DREADNOUGHT.—[See page 118.]

Protection of Battleships Against Submarine Attack*

By Sir John H. Biles, LL.D., D.Sc.

DESIGN OF A BATTLESHIP

Fig 1 RIGGING PLAN.



PROFILE SHEWING SUBDIVISION.

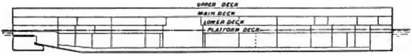
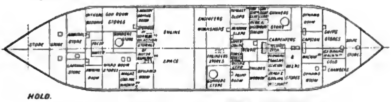
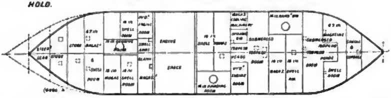


Fig. 2. PLATFORM DECK.



HOLD.



In this Institution we have a meeting ground for the statesman, the naval officer, and the ship constructor. The first directs the second, and the third supplies the second with his weapon. We ship constructors are sometimes taken into the confidence of the naval officer, and we try to understand as much as we can of the nature of the onerous duties which he has to perform. We are told that the navy exists to keep the command of the sea, and that command of the sea is necessary for its freedom. To keep the command it is desirable—some say, necessary—to discover and destroy the enemy's forces. Battleships, cruisers, destroyers, submarines, must all be caught and destroyed or captured, and, equally, all must be capable of resisting destruction or capture. In the two dimensions represented by the surface of the sea, with equal powers of vision, getting within destroying distance is a question of speed, and destruction is a matter of superiority of attack over the defense. The dominating weapon of attack has been the gun, and the defense against it has been practically all above water, because there its attack has been made. The torpedo-boat and, later, the destroyer, have delivered their main attack below water, but the attacked ship is held to be quite capable of delivering a counter attack by guns above water, which is an adequate reply to the destroyer. The attack of the submarine is wholly below water, and so far the attacked ship has developed no effective reply of its own. The defense against the gun is armor and other guns. The defense against the destroyer's torpedo is the gun, which is quite ineffective against the submarine. The question of interest at the moment is: What defense can the surface ship have against the submarine's torpedo?

There can be only two forms of defense. First, the destruction of the submarine by other vessels, submarine or others. Second, the protection of the bottom of the surface ships from the effects of under-water attack. The first, the destruction of the submarine, is obviously not the work of a battleship or large cruiser, but must be left to some vessel of the same order of size as the submarine. This destruction must be sought on the surface when the submarine is not submerged, for it seems improbable that a submarine will be able to chase another effectively under the water. In any case, the submarine will be dangerous to the large surface ship until it is destroyed, and, as the means of destruction are not yet certainly to hand, the question of effectively protecting the battleship against under-water attack seems to be deserving of consideration, unless someone is ready with a real reply to the submarine.

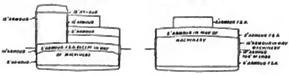
One naturally is first met with the question: What about the weight of such protection? The same question can, of course, be asked in the same attitude of mind about any weights used in a ship for the purpose of attack or defense. What about the weight of armor to keep out shot? The thickness and extent of protection ought to be proportioned to the liability to be hit and the damage done when hit. This principle is given effect to when distributing armor protection over a ship to resist gun fire. What is the relative damage done by a 15-inch shell and a 21-inch torpedo, and what is the relative liability to be hit by these projectiles? A distinguished gunner told you in this Institution in April that a modern battleship will be destroyed by gun fire in five minutes after fighting range has been reached. The submarine officer will tell you he can get a torpedo into any ship that he can see and can get within the range of his torpedo. The battleship can hit back at his enemy battleship, but can do nothing by himself against the submarine. What is the liability to be hit in the two cases? Can the submarine find the battleship as surely as the enemy battleship can? In other words, what is the relative liability to be hit by the two methods of attack? This is for the naval officer to tell us, if he can. If the relative liability to be hit is sufficiently great to warrant full consideration of the relative damage, we shall also want to know this. Assuming, as one reasonably may, that very serious damage will be done by the explosion of a torpedo, the next question is: What can be done to prevent or seriously to reduce this damage? Subdivision naturally suggests itself as one means of minimizing the effect of this damage, but when all that is possible in this direction has been done, there seems to be no great certainty that a battleship will be still a formidable fighting machine after having received the successful contact explosion of a 21-inch torpedo. Can we do anything in addition to subdivision to preserve the ship for effective fighting purposes?

Armor on the bottom of warships has been proposed by responsible persons. Sir E. J. Reed and General Sir John Crease, R.M.A., during their lives made definite proposals of this character, but they have never been adopted on the outsides of ships, partly for the reason that, previous to the submarine, the torpedo-carrying vessel has been effectively answered by the gun, and partly because the resisting qualities of armor, when submitted to attack by torpedoes, have not been sufficiently well known. The effective advent of the submarine seems to justify a serious consideration of the question of applying armor to the bottoms of ships.

The question of the weight of such armor must be serious, and obviously the addition of such weight cannot be made without some changes and sacrifices. To some it may seem that the readiest way to approach this problem is to clothe the bottom of a 25,000-ton battleship of the latest pattern with armor, and to increase her fullness sufficiently to allow her to carry this armor, letting everything else remain unaltered. The only considerable affect will be to reduce the speed by two knots.

This is a direct and simple issue—is the gain in pro-

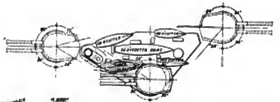
Fig. 3.


SECTION IN WAY OF AMIDSHIP BARBETTE

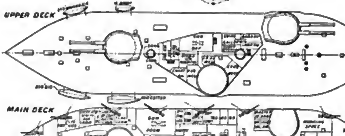
SECTION IN WAY OF MACHINERY SPACE

Fig. 4.

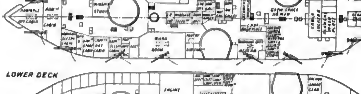
BOAT DECK.



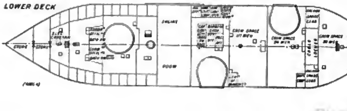
UPPER DECK



MAIN DECK



LOWER DECK



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* Paper read before the Institution of Naval Architects at Newcastle, on July 7th, 1914.

tection worth the loss of speed? This is for the naval officer to decide. The constructor will naturally find difficulties in the way of attaching such armor protection, but he has surmounted difficulties before, and if the naval officer thinks the result worth attaining, the difficulties will doubtless be overcome.

It is not always that the readiest way of approaching a problem gives the best result. One of the characteristics of our latest battleships is that their forms have a low resistance to forward motion. If a form is produced which is better adapted to fitting and carrying armor, though it may involve greater resistance or less speed, it may on the whole be better to adopt such a form. It may be interesting to give an instance or two of the application of this principle. Admiral Sir Reginald Custance has taken us into his confidence about some of his views on the principles which he thinks should underlie naval design. His appreciation of lower speeds and smaller displacements led me to work out what appeared to me to be a limiting case of his views, but combined with these characteristics was associated in this case an armored protection from torpedo attack. The principal elements of the resulting design were as follows:

Length over all	358 ft.
Length between perpendiculars	336 ft.
Breadth, extreme	90 ft.
Draught of water	20 ft.
Displacement in tons	13,000
Speed	10 knots
Armament	six 14 in.; sixteen 5 in.
Thickness of armor:	
On side at W. L.	10 in.
Above W. L.	3 in.
Below W. L.	4 in.
On casemate	2 in.
On barbettes	12 in.
Thickness of protective deck-plating	2 in.

This vessel may be considered as one which could not be expected to find the enemy unless he happened to be bottled up somewhere, but could be less careful than an ordinary battleship about coming out of port on account of the fear of submarines. The size and cost of this vessel should be small enough to satisfy the desires of Admiral Sir Reginald Custance, but it is doubtful whether she would be altogether satisfactory to him.

Anticipating some want of faith in this unusual vessel, a second design was produced, having some of the characteristics of the first, but being produced with less disregard of convention. The principal elements are as follows:

Length over all	460 ft.
Length between perpendiculars	434 ft.
Breadth, extreme	80 ft.
Draught of water	24 ft.
Displacement in tons	16,000
Speed	18 knots
Armament	six 14-in.; sixteen 5-in.
Thickness of armor:	
On side at W. L.	5 in.
Above W. L.	5 in.
Below W. L.	4 in.
On casemate	2 in.
On barbettes	5 in.
Thickness of protective deck-plating	2 in.

This vessel is of about the displacement of the "Lord Nelson," which is, when purpose serves, called a dreadnought. The armament is about the same as the first design, but the armor has been reduced so that it will only keep out 6-inch projectiles. Sir Reginald's view is that none of our ships have armor that will do more, and, that being so, this ship may be considered as sufficiently well armored above the water-line. All the sections below the water-line are straight, with a circular arc at the end. This form has been adopted to simplify the armor construction of the bottom. It is fully recognized that such a design outrages the convictions of the economists, to whose ranks I want to belong, because ships of such size do not produce the greatest number of guns for a given expenditure. But if we are to be subjected to the ready loss of ships by submarines, we may have to be prepared to sacrifice some gun power for our expenditure, and get our recompense in the greater number of ships and guns remaining afloat after the submarine has done its work. It is very rash on the part of a mere naval architect to attempt to reach any conclusion on this difficult question. The facts and figures are placed before this Institution, so that those who are competent to form an opinion may have the opportunity of doing so.

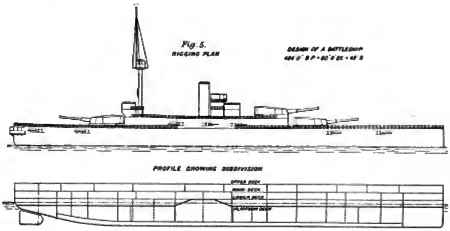
Fig. 5.

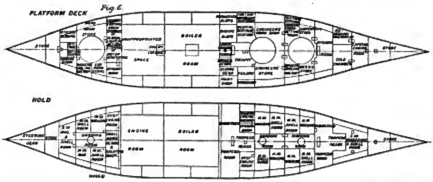
Fig. 6.

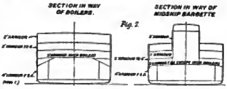
Fig. 2
SECTION IN WAY OF BOILERS.
SECTION IN WAY OF MIDSHIP BARBETTE

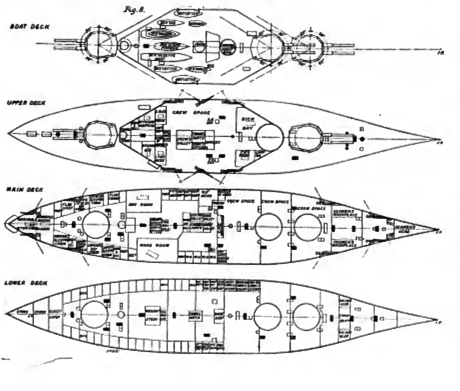
Fig. 8.

With a view of enabling those who do not believe in reducing the upper armor of a ship, nor in such a low speed as 18 knots, another design has been considered in which the bottom is armored, and is of a form similar to the second design, but in which the speed, armor, and armament are of the same order as the dreadnoughts. Such a vessel could take her place in the first or second battle squadron, and would have armored protection against torpedoes. The principal elements are as follows:

Length over all	600 ft.
Length between perpendiculars	570 ft.
Breadth, extreme	91 ft.
Draught of water	28 ft. 8 in.
Displacement in tons	28,500
Speed	21 knots
Armament	ten 14-in.; sixteen 6-in.
Thickness of armor:	
On side at W. L.	10 in.
Above W. L.	7 in. and 5 in.
Below W. L.	4 in.
On casemate	2 in.
On barbettes	12 in.
Thickness of protective deck-plating	3 in.

Briefly, the points for discussion are as follows:

1. Is 4-inch armor sufficient protection against torpedoes to justify its adoption in battleships of the class of the later dreadnoughts?

2. Is the submarine menace of sufficient importance to justify the adoption of 4-inch armor protection on the bottom?

3. Is the submarine menace of sufficient importance to justify the building of smaller, slower battleships of, say, 16,000 tons displacement, of 18 knots, having six heavy guns each instead of eight or ten as in the larger ships?

4. Is the method of applying armor to the bottom of sufficient value in itself to justify the adoption of a form of ship which offers greater resistance than the ordinary form?

These are some of the points which suggest themselves for discussion. The form and arrangement of existing ships, though not revealed to us by the Admiralty, may be considered, for this purpose, as sufficiently well known to many to make it unnecessary for a third design to have been embodied in this paper. If it should seem to be desirable, further, to consider this question of protecting battleships from submarine attack, it will be necessary to determine by experiment the effect of the explosion of a torpedo upon armor attached to a ship. If the submarine menace is judged to be really serious, the necessity for carrying out such experiments seems to be undoubted.

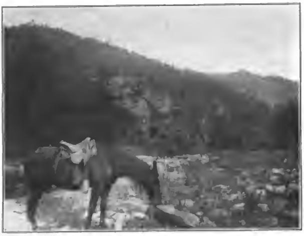

Fig. 1.—Railroad tunnel piercing nearly vertical layer of Lee conglomerate near Big Stone Gap, Va.

Fig. 2.—Typical scene in Letcher County, Ky., showing log cabin and path leading to coal opening in the mountain side.

Coal and Its By-Products—I[*]

How, and of What Coal Was Formed, and Some Account of Its Utilization

By Louis Cleveland Jones, Ph.D.

There have been listed and described perhaps several hundred thousand organic compounds, practically all of which can be obtained directly or indirectly from the decomposition of coal by heat.

Carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorus, and the halogens are normal constituents of ordinary coal, so that all compounds containing any or all of these substances, in any proportion, are possible direct by-products of coal. Coal also at times contains unusual constituents such as the rare elements in the ash, even gold and radium. We have known a coal ash to contain so much gold that the possibility was considered of treating its ash after burning, as a gold ore. There are seams of coal in southern Indiana and eastern Kentucky which contain iron ore. The ash of some coals in western Pennsylvania and eastern Kentucky makes an excellent high-grade, refractory fire-clay. One of the principal coal seams in Illinois consists of an upper bench of limestone.

But the true by-products of coal are the organic products, and they are so numerous that it would weary you to mention even all their group names. Acid bases, alkaloids, alcohols, gums, varnishes, solvents, sugars, saccharine, and stuffs as bitter as saccharine is sweet, disinfectants, dye stuffs of brilliant hues, stimulating or sleep-producing drugs, healing medicines and violent poisons, vile odors and pleasing perfumes, are all by-products from the carbonization of coal.

But I must not weary you with the recital of these products and their nature, for I wish to consider the nature of coal itself.

In order more clearly to understand what coal is, we must look into its origin.

EARLY ATMOSPHERE OF THE EARTH.

A generation ago it was not good science to talk much about transmutation. However, after the recent accomplishments of Madam Curie, Sir William Crooks, Prof. Rutherford, and others, transmutation has been brought again into the realm of science.

After the primordial substance had been transmuted into some eighty present well-known elements, and these were still in the condition of vapor uncondensed, there was present, fortunately, sufficient oxygen to combine with all the other elements which cared to associate with it, and just a little more. These vapors cooled and condensed to a molten mass in the form of a sphere—our earth. Forty-five per cent of the earth's crust, say one quarter of the whole weight of this sphere—the earth—is represented by the oxygen which has combined with other elements to form rocks and water. One quarter of the weight of the earth represents 32 billion trillion tons of oxygen, and there was left over uncombined in our atmosphere 670 trillion tons, or only two millionths of one per cent of the total. So you see that it is by a rather close margin that we now have enough oxygen in our air to enable human beings to live.

The earth, now cooled to the condition of a fairly homogeneous fused mass of rocks, may be compared with a tank of fluid melted glass, composed of impure mixed silicates with an excess of silica, about 75 per cent of the total weight of the earth's crust, while the mixture in an ordinary glass furnace contains also about the same percentage (70 to 75 per cent) of silica.

Above this fused mass was an atmosphere containing the present amount of air (nitrogen and oxygen), and also as steam all the water now condensed in the ocean, and all the carbon dioxide now fixed in the form of limestone (calcium carbonate). There was also present, of course, in that atmosphere, relatively small amounts of sulphur and halogens, since deposited as salts.

A rough estimate indicates that the total amount of water now in the world, if evenly distributed, would cover all the earth's surface 10,000 feet deep (say 3,000 meters).[1] Likewise the limestone deposits of the earth's surface are, on the average, 6,000 feet (say 1,800 meters) deep.

On this basis, then, and since one atmosphere equals 10 tons per square meter of surface, we can readily calculate that, with all the water as vapor, and all the carbon dioxide as gas in the atmosphere, the pressure upon the earth's surface would be enormous, i. e.:

=300 atmospheres water vapor.
200 atmospheres carbon dioxide.
1 atmosphere nitrogen and oxygen.

Thus the earth's atmosphere was composed, by volume, of

	Per Cent.
Steam	79.2
Carbon dioxide gas	20.4
Air (oxygen and nitrogen)	.35

all under a pressure of say 600 atmospheres, or 7,350 pounds per square inch. Under these conditions cooling was rapid, due to the continuous condensation of water vapor high in the atmosphere, and its re-evaporation lower down.

When the earth's crust became sufficiently cool the solid granite masses, thrust up by contraction, were violently attacked by this superheated steam and carbon dioxide under tremendous pressure. Decomposition of the granite was rapid, with formation of shales (aluminium silicates) and bases (alkalies and alkaline earths) from feldspars, and sandstones (silica) from quartz. Cooling continued below the boiling-point of water so

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[*] Presented at the meeting of the Section of Physics and Chemistry of the Franklin Institute, and published in its *Journal*.

[1] Calculated from average depth of oceans as determined by measured speed of volcanic tidal waves crossing the Pacific.

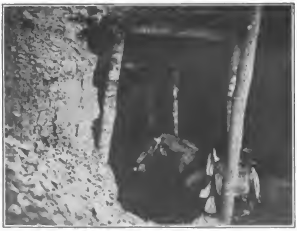

Fig. 3.—The thickest opening in Elkhorn seam, Kentucky. The horse is standing on a level with the bottom of the coal seam.

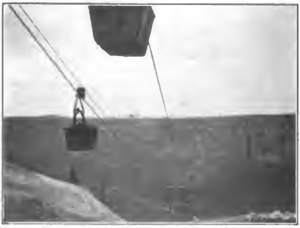

Fig. 4.—Bucket cable line bringing coal across a valley in eastern Pennsylvania.

that most of the water condensed, leaving a moist atmosphere containing principally CO_2, i. e., over 98 per cent of CO_2, and less than 2 per cent of nitrogen and oxygen together.

In these warm waters shales and sandstones were sedimented, and at the same time lime from the decomposed granites was carbonated or bicarbonated and deposited to form the enormous limestone beds of the geologic ages preceding the coal-forming era.

Since our limestone deposits are generally sedimentary it is evident that much water had condensed before the great bulk of the carbon dioxide was taken from the air by the decomposing granites. At any rate, in this manner, at the same time water was condensed, or subsequently, the formation of limestone (possibly, as Dana says, by means of animal or vegetable organisms), with absorption of carbon dioxide, continued until, with decreased temperature and decreased amounts of carbon dioxide in the air, plant and animal life became possible. Experiments indicate that plants of our time will not thrive in an atmosphere containing more than 10 per cent of carbon dioxide, but that they do benefit considerably by percentages higher than normally present in our air. Certainly in the carboniferous era plant life flourished as never before or since, due to a warm, moist climate, and probably also to high atmospheric pressure, and particularly in the presence of a moderately high percentage of carbon dioxide. Possibly also the highly carbonated earth waters, as recent experiments suggest, stimulated a luxuriant growth of vegetation.

Fig. 5.—Typical drift mine in Tug River district, West Virginia.

AMOUNT OF CARBON DIOXIDE IN THE ATMOSPHERE IN COAL ERA.

The ratio of the thickness of limestone beds, deposited before the beginning of the coal-forming era, to the limestone formed from granite decomposed since, would permit us to calculate what amount of the 98 per cent of carbon dioxide originally present remained in the atmosphere when our coal beds were formed. Such estimates are extremely indefinite, but it is quite probable that the atmosphere of the coal-forming era contained from 2 to 5 per cent of carbon dioxide, while at present, as we know, we have but 0.03 of one per cent. Furthermore, this carbon dioxide and high moisture content of the air doubtless brought about a more uniform distribution of heat, so that at any rate tropic vegetation flourished from the equator to the poles.

In addition to the absorption of carbon dioxide during and since carboniferous times to form limestones, the great coal deposits of the world have taken their carbon equivalent from the carbon dioxide of the atmosphere.

CO_2 REQUIRED TO FORM COAL.

A committee of the Twelfth International Geological Congress, held in Canada last fall, determined the total minable coal deposits of the world to be at most 7,400 billion tons. Double this, or 14,800 billion tons, may be taken to safely represent all other coal in thin seams beneath the ocean and in other ways not minable.

Now, if we compare our total coal deposits, 15,000 billion tons (calculated into its equivalent of carbon) with the 0.03 per cent of carbon dioxide still in our atmosphere (equivalent to 700 billion tons of carbon), we get the striking information that the coal deposits of the world required and took from the air 11,000 billion tons of carbon for their production, and there are left in the air to-day but 700 billion tons of carbon, or but 6 per cent of the total originally required to produce the coal we have. In other words, no more coal could have been deposited because the raw material was practically used up. This world cannot, therefore, have another carboniferous era until we burn up our present deposits, and when we do get them burned up there will reasonably be, say 0.6 per cent more CO_2 in the atmosphere, and the same amount less of oxygen than at present.[4]

FLUCTUATIONS OF CARBON DIOXIDE IN THE ATMOSPHERE.

How much carbon dioxide has been absorbed by granites decomposed since the beginning of the carboniferous age is not readily determined, but the larger amount present at that time, besides directly giving richer food to plant life, has been considered sufficient to so modify climate as to account for the tropical conditions prevalent at that time.

Arrhenius and Chamberlain have attempted to explain the known fluctuations of climate as indicated by glaciation by corresponding fluctuations in the carbon dioxide of the atmosphere. But a sufficient cause for such changes in the amount of carbon dioxide is hard to find. We may estimate the earth's water to contain perhaps seven parts carbon dioxide per one hundred thousand, in the form of bicarbonates, more than sufficient if transferred to the atmosphere to supply carbon for another coal-forming epoch, but boiling would be required to drive it into the atmosphere.

The decomposition of a small portion of the limestone, by heat or otherwise, would, of course, return the requisite amount of carbon dioxide to the air to give again to earth universal tropical conditions. Without heat, however, an acid would be required to evolve carbon dioxide, but no such acid suggests itself other than a rather improbable one, i. e., nitric acid, formed by oxidation of nitrogen by electrical discharges which the earth in its history may have developed or encountered.

AMOUNT OF CARBON DIOXIDE NOW IN ATMOSPHERE CONSTANT.

It would not be unreasonable to estimate that the ordinary growth of vegetation and forestry may consume 400 grammes of carbon dioxide per square meter of surface per year, or 100 grammes per square meter over the entire surface of the earth, or about 2 per cent of the 4,400 grammes of CO_2 in our present atmosphere. The production of carbon dioxide by the 1,200 million tons of coal annually consumed is but one seven hundredth part of the carbon dioxide already in the air. At any rate, the present increase or decrease of the carbon dioxide in the air is not perceptible by present means of analysis. Any further decomposition of granites, though now slow, due to the comparative small amount of the rock exposed, must absorb a corresponding amount of carbon dioxide from the air, and when the minutest amount more has been absorbed, compared with what has already been accomplished by such decomposed granite, no more carbon dioxide will remain to sustain plant life and the earth will become a dead world. But granites, beside being protected (covered up) from weathering, are also decomposing more slowly because of the comparatively low temperature and low pressure of the atmosphere acting upon them. Since observations have been made, no diminution of the carbon dioxide in the atmosphere has been observed.

MINABLE COAL RESOURCES OF THE WORLD.

In the following table are given the coal resources of the world, and on this basis it will not be difficult to predict great commercial growth in such nations as China, when once she has had a generation of technical education.

The present production, however, of coal in China, as given for 1910, is only a little over one half that of Belgium.

COAL RESOURCES OF THE NATIONS OF THE WORLD.
(In million tons.)
(From data in report of committee of Twelfth International Congress of Geology, Canada, 1913.)

Nation.	Anthracite.	Bituminous.	Sub-bituminous.	Total.
United States	19,684	1,955,521	1,863,452	3,838,657
North America (except United States)	2,158	284,162	948,454	1,234,774
China	387,464	607,523	600	995,587
Germany	......	409,975	13,381	423,356
Asia (except China)	20,173	152,575	111,251	283,999
Great Britain and Ireland	11,357	178,176	......	189,533
Oceania	659	133,481	36,270	170,410
Europe (except Germany, France and Great Britain and Ireland)	39,718	92,331	21,669	153,718
Africa	11,662	45,123	1,054	57,839
South America	700	31,397	......	32,097
Total	496,846	3,902,944	2,997,763	7,397,553

(Note enormous deposits of anthracite in China.)

From the following table, showing the annual coal production of the principal countries of the world, and the table calculated from it, showing the percentage increase in production by five-year periods, we are able to predict with some degree of certainty a comparatively early exhaustion of the coal resources of the world. The incomplete data for the years succeeding 1910 show no falling-off in this production of coal, but, in fact, it is already evident that the normal five-year increase will be exceeded by 1915.

INCREASE IN COAL PRODUCTION BY FIVE-YEAR PERIODS FROM 1865 TO 1910.
Percentage increase over previous period.

	1865 to 1870.	1870 to 1875.	1875 to 1880.	1880 to 1885.	1885 to 1890.	1890 to 1895.	1895 to 1900.	1900 to 1905.	1905 to 1910.	Average.
United States	21	61	38.5	53.0	38.0	26.0	37.0	44.0	27.0	38.4
World	19	14	19.0	21.5	24.3	13.3	31.6	21.3	23.3	20.8

Thus coal production of the world doubles every 20 years, and of the United States doubles every 11 years.

On this basis, the world's resources will last 250 years, while the United States at her higher increase in production would exhaust her own enormous supply in 110 years.

Furthermore, if we purchase coal lands now in the United States at present values, say 2 cents per ton in the ground, and charge against this investment compound interest at 6 per cent, such unused coal as we may have unmined at the end of 120 years will have cost us $20 per

TABLE OF THE ANNUAL COAL PRODUCTION OF PRINCIPAL COUNTRIES OF THE WORLD.
(In million tons.)
(From Report of Twelfth International Geological Congress, 1913.)

Country.	1865.	1870.	1875.	1880.	1885.	1890.	1895.	1900.	1905.	1910.
Australia	......	......	......	......	......	......	4.01	6.48	6.83	10.00
New Zealand	......	......	......	......	......	......	0.76	1.11	1.41	2.23
China	......	......	......	......	......	......	......	......	......	14.50
India	......	......	......	......	......	......	2.65	6.22	7.92	12.09
Japan	......	......	......	......	......	......	4.84	7.43	11.89	14.79
South Africa	......	......	......	......	......	......	1.40	0.76	3.22	5.50
Canada	......	......	......	......	......	......	3.19	5.09	7.96	13.01
United States	24.79	29.95	48.20	66.83	102.18	141.62	177.59	243.41	351.12	415.81
Mexico	......	......	......	......	......	......	......	......	......	2.45
Great Britain	99.76	112.24	135.49	149.38	161.90	184.50	194.35	228.77	239.89	264.50
Spain	0.45	0.66	0.61	0.85	0.94	1.18	1.77	2.58	3.20	3.55
France	11.84	13.30	16.95	19.36	19.51	26.08	28.24	33.40	36.05	38.57
Belgium	11.84	13.69	15.01	16.88	17.44	20.37	20.41	21.46	21.84	23.13
Germany	28.33	34.88	48.53	59.12	73.67	89.29	103.96	149.79	173.66	221.98
Austro-Hungary	2.03	8.36	13.06	14.80	20.43	26.10	27.25	39.03	40.72	38.18
Italy	......	......	......	......	......	......	0.26	0.48	0.31	0.40
Sweden	......	......	......	......	......	......	0.20	0.25	0.33	0.21
Russia	0.33	0.69	1.17	3.27	4.24	7.00	9.10	11.76	17.12	24.57
Other countries	2.71	1.04	6.26	9.28	12.45	16.80	1.75	2.90	4.55	8.00
Total	182.08	217.81	285.30	339.37	412.82	513.12	581.72	765.92	928.02	1,143.38

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[4] Sir William Herschel calculated the total weight of the earth's atmosphere as 11¾ billion tons. It is really 11¾ quintillion pounds or 5,800 trillion tons, five hundred times Sir William's figure.

ton, or say f.o.b. cars $21, the same figure that White & Hazard paid for coal 100 years ago. Two cent coal carried under the same conditions 250 years would cost about $40,000 per ton. So we see that it is practically immaterial to our posterity whether any coal lasts 250 years or not. Its price would be prohibitive, but of course prohibitive prices can never be maintained.

COALS ARE RESIDUES OF CARBONIFEROUS VEGETATION.

Now, we have 7,400 billion tons of minable coal, but of greatly different varieties. And though capable of producing an enormous number of by-products, the substance of the different coals is not so mysterious if we remember that each variety of coal represents only a different step in nature's slow process of converting the vegetation of the carboniferous era into the fuels so necessary to our modern civilization.

Essentially, therefore, coal was originally wood (cellulose) $(C_6H_{10}O_5)_n$ and resins, now converted in the age-long processes of nature into peat, lignite, semi-bituminous, bituminous, gas coal, smokeless coal, semi-anthracite, anthracite, graphite, diamond, and we might also place carbon dioxide, the raw material from which wood is made, at the head of the series.

It is thus quite remarkable that our fuel coals, near the end of the series, upon burning return again to the air as carbon dioxide, to be converted by photo-chemical processes a second time into vegetation (wood), and thus repeat the cycle of the carboniferous age. But geological ages are made up of cycles of incomprehensible lengths of time. So here when we seek the origin of graphite which is found in the granites of the archaic ages, we can only answer, a previous carboniferous era.

This series of products, with the geological and paleobotanical evidences of its succession, is so reasonable that there can be little doubt that it accurately represents ancient vegetation in the different stages of carbonization in nature's by-product retort.

The earth's crust is such a retort, and the by-products have been saved in the form of asphalt, bitumen, petroleum and natural gas.

We may estimate that over 70 per cent of the weight of wood is lost in being converted to coal, and, according to tests, which follow, possibly one half of this loss was carbon dioxide and the other half combustible gas and oils. This oil and gas, nature's by-products, stored beneath folds of rock strata, constitute our present sources of petroleum and natural gas.

(To be continued.)

Submarine and Dreadnought

Which Will Survive? Steam Battleships Are a Century Old, But Submarines Are Much Older

By Willis Fletcher Johnson

SIR PERCY SCOTT has stirred the admiralties of the world as they have not been moved for many years; since, let us say, the epochal duel between the "Monitor" and the "Merrimac." For this great naval authority, one of the highest in the world, practically pronounces big battleships obsolete. The dreadnoughts and superdreadnoughts, costing ten million dollars each, which all important naval powers are building with feverish zeal at the rate of from one to four or five a year, and which are regarded as the criterion of a navy's strength, have been rendered worthless. The submarine has relegated them to the realm of the dodo. It would be folly to build more of them, and those already built may as well be consigned to the scrap yard. Thus Admiral Sir Percy Scott, in re-emphasized repetition, clearly sets forth much of what was said to the same effect by a distinguished Frenchman, Admiral Fournier, some eight years ago.

It must be confessed, parenthetically speaking, that one of Sir Percy's arguments seems strangely unconvincing, particularly when coming from an officer of the British navy. If the building of submarines keeps on, he says, "it will not be safe for a fleet to put to sea." Doubtless not; but when was it ever safe for a fleet to put to sea, in time of war? Not in the days of Salamis, of Actium, of Trafalgar, of Santiago, of Tsu Shima. It was not safe for Nelson to go in Trafalgar, or for Farragut to enter Mobile Bay. But they did not hesitate on that account. Fleets do not put to sea for safety. They go out anticipating and indeed actually seeking deadly danger, but intent upon making the enemy's danger greater than their own. The question is, therefore, not whether submarines are dangerous to dreadnoughts—as of course they are—but whether, in spite thereof, the dreadnoughts are still more dangerous to the enemy.

That, however, by the way; for I am not discussing the relative efficiency of the two classes of vessels. The fact which I wish to recall is that if the submarine should replace the battleship, we should really be reverting to the earlier type, since the submarine considerably antedates the armored steam battleship; though both were devised by the same inventive genius, the later of the two just a hundred years ago. This summer marks the centenary of the first steam warship, which was also the first armored battleship, albeit its armor was of wood, and which, because of its supposed impregnability, may be regarded as the prototype of the dreadnought class. But it is much more than a hundred years since the first submarine vessel was built, tried, and proved to be efficient, yet strangely rejected by a power whose acceptance of it might have transformed the history of the world.

Robert Fulton was the originator, in practical form, of both the submarine and the steam battleship, and also of the torpedo, the last named being essential to the utility of the submarine and indeed suggesting the invention of it. Before his time explosive mines had been used in naval war—note the "Battle of the Kegs" in our revolution—but they were merely set adrift or anchored fast. It remained for Fulton to devise a method of directing their course, and then, because of their dirigible mobility, to name them after the shock-giving fish.

So, too, attempts at submarine vessels had been made before him. William Bourne suggested and described one as far back as 1578; and in 1621 Cornelius van Drebbel is said to have "built a ship which one could row and navigate under water from Westminster to Greenwich; even five or six miles, or as far as one pleased", but no plans of it have been preserved, and the existing descriptions are too vague to afford any definite idea of its construction. David Bushnell of Connecticut was more successful. In 1776 he built a small vessel shaped like a turtle, which was apparently not to go entirely under the water, but was to float with the crest of its dome just above the surface, its rounded contour rendering it practically impregnable to cannon shot. It was to drift with the tide near enough the enemy's vessel to permit its occupant to thrust an explosive against it. Two practical tests of the craft were made in 1777, against British ships. The first, in the Hudson River, was entirely unsuccessful. The second, in the Connecticut River, resulted in blowing up another vessel than that intended. Bushnell then went to France and continued his experiments, but achieved no further success.

It is altogether probable that Fulton was acquainted with Bushnell's device, since a pretty detailed description of the latter was published in 1795, and his own subsequent invention markedly resembled it in several essential respects. So, too, Fulton doubtless got some ideas of the steamship from former attempts of other men; and so Morse got ideas of the telegraph. The essential circumstance is, however, that Fulton, like Morse, so greatly improved upon the plans of his predecessors as to succeed where they failed; or where, at any rate, they did not succeed.

The description of Bushnell's vessel was published in France in 1795. Two years later Fulton proposed to the French government the construction of what he called a "Mechanical Nautilus," to destroy the British fleet. There arose at once, however, a serious difficulty over a matter of law. Such a device was regarded as contrary to the rules of civilized warfare, and those operating it would therefore be outlaws and not entitled, in case of capture, to the immunities of prisoners of war. In order to secure protection, if possible, for those who should man the submarine, Fulton stipulated that the French government should make it known that if they were put to death it would retaliate fourfold upon the British prisoners in its possession. To this the French government demurred, largely on the very practical ground that there were more French prisoners in the hands of the British than British in the hands of the French, and that therefore in a contest of reprisals the French would suffer most. So it declined to give commissions in its navy to the crew of the "Nautilus," and finally rejected the whole scheme.

The next year, 1798, Fulton renewed his proposals. That was the year in which Nelson destroyed the French fleet at the Nile, when, if ever, France needed aid against the sea power of Britain. He made known the general principles of his scheme. The submerged boat was to be driven by a screw propeller, operated by hand power. It would have a speed of several miles an hour and would be perfectly dirigible, and could remain entirely under water for an hour or more. A French government commission examined into it, pronounced it a work of genius, and recommended its acceptance. Had this recommendation been promptly and energetically acted upon, Bonaparte might have conquered England and the history of the world might have been changed. But it was not acted upon. On the contrary, nothing at all was done.

Fulton, however, persevered. He proceeded with the building of a submarine, and on July 24th, 1800, launched it in the Seine at Rouen. Five days later the first practical trial was made. Fulton and two other persons went down in the boat and remained submerged for eight minutes. The second time they remained down for seventeen minutes, in twenty-five feet of water. The boat was twenty feet long but only five feet in diameter, so that the men could not stand upright. But it was proved that it could sink and rise again, and be propelled and steered under water.

A few days later Fulton took the vessel to Havre and experimented with it in the harbor. He repeatedly remained submerged at a depth of fifteen feet for an hour or more, sometimes alone and sometimes with two passengers. Also, he successfully discharged a torpedo against a cask used as a target. On September 12th he left Havre for La Hogue, steering boldly across the open sea, and making four and a half miles an hour. On September 16th he remained below the surface for six hours at once, drawing supplies of air through a tube, the end of which floated upon the surface. Near Isigny he attempted to approach some British ships, but was unable to do so. He made the trip to La Hogue, however, more than seventy miles, in safety, and thus abundantly demonstrated the navigability and the seaworthiness of the little craft.

From La Hogue he conveyed the boat overland, on a cart, to Brest, where he launched it again and made further highly successful experiments; or, rather, demonstrations, for the thing had passed the merely experimental stage. An old sloop was set as a target, and he demolished it completely with a single torpedo, at the first attempt. But at this time Moreau was vanquishing Austria and Bonaparte was conquering Italy, and the Directory underrated the value of sea power compared with triumphs on land. So no terms satisfactory to Fulton would be considered, and the great inventor finally gave up his efforts. He tore the hull of the "Nautilus" to pieces, broke up the machinery, and left nothing which could give anyone a hint as to how to reconstruct the vessel. He retained detailed drawings of all parts of it, but he refused to show these to the French government, and took good care to keep them where that unappreciative body could not get hold of them. He lost some thousands of dollars which he had spent from his own pocket on the enterprise. But France lost her only chance of gaining the mastery of the sea and of conquering her island foe. And a little after that came Trafalgar.

Fulton then turned his attention from ships of war to ships of commerce, and seven years later revolutionized navigation with the "Clermont." But when our second war with Great Britain came on, he set about applying his great invention of steam navigation to the navy. Obviously, the first requisite of a steam warship was that it should be so armored that the engine would be safe from cannon shot. The paddle wheels must also be protected, which in the "Clermont" and other steamers were openly exposed. Strangely enough, he did not attempt to apply the screw propeller, which he had devised and used years before, but left that for John Ericsson in after years. Instead, he designed a craft which somewhat resembled a catamaran, and somewhat, also, a single very broad hull with a big well-hole in the center. It resembled a catamaran in having two parallel keels. But the two hulls were connected at bow and stern, into a single bow and a single stern, to a point below the water-line. Thus the single huge paddle wheel in the central space between the two hulls was protected at bow and stern from raking fire, as well as at the sides. The ship was simply a broad oval floating battery, with engine below the water-line and wheel in a central well-hole.

I have spoken of this as an armored vessel. It was. The sides were of solid oak timber, 5 feet thick. They were thus as impervious and impregnable to the cannon shot of those days as are the 10 or 12-inch steel plates of a modern dreadnought to the projectiles of our time. The vessel was to be heavily armed, too, with what were for that time big guns. It was to carry twenty

100-pound Columbiads; so called by Fulton in honor of his friend Joel Barlow's epic, "The Columbiad." These were to be placed two at the bow, two at the stern, and eight on each side. Moreover, it had several similar guns which were to be fired below the water-line, as torpedoes are now discharged; Fulton's last patent being for such ordnance. Of course, cannon shots under water would not carry far; but when vessels were only a few feet apart, or actually touching sides, as often happened in those days, such fire would be tremendously effective.

This vessel, named by Fulton the "Demologos," was designed in 1813. Congress in March, 1814, authorized its construction, and Fulton set to work upon it promptly. The keel was laid on June 20th, 1814, in the shipyard of Adam and Noah Browne, on the East River, New York, and on October 29th the ship was launched. It was 167 feet long and 57 feet broad, and had 12 feet depth of hold. Its engines were of 120 horse-power. Fulton promised that it would make four or five miles an hour, but it actually made 6.4 miles, and despite its clumsy shape was very easily steered. As it drew only 11 feet, it could traverse most navigable waters; certainly going wherever a line-of-battle ship or even a big frigate could go. Fulton modified its armament, however, giving it thirty long 32-pounders instead of the twenty 100-pounders which were at first intended. The total cost of the ship was about $240,000.

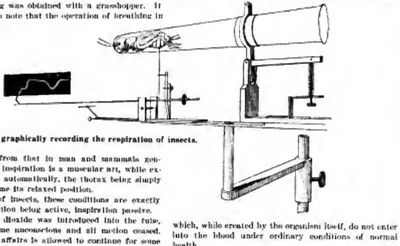
The trial trip was not made until June 1st, 1815. On July 4th of that year it made the 53-mile trip to Sandy Hook and back at an average speed of 6.4 miles an hour; but as the war with Great Britain was ended, it was not needed for service. So it was laid up at the Brooklyn navy yard as a receiving ship, and upon Fulton's death in that same year it was renamed after him. It was its inglorious fate, on June 4th, 1829, to be destroyed by an accidental explosion, which also cost the lives of twenty-five men. It may be added that the British Admiralty also began, shortly after the building of the "Demologos," the construction of a steam warship, a sloop named the "Congo." But because of the ending of the war with America it was altered into a sailing vessel, and the engine which had been made for it was used for pumping at the Devonport dockyard.

The interest which Fulton's warship excited abroad was very great, though the public was not well informed. All sorts of extravagant tales about the "Demologos" got abroad and were credited. Perhaps the most picturesque was that which was published in the *Evening Courant* of Edinburgh, Scotland, at the end of August, 1815—an account which was given seriously, from a correspondent who had taken pains to secure full and accurate information. It described the vessel as 300 feet long and 200 feet wide, with walls 13 feet thick, of alternate layers of oak and cork! It carried four 100-pound and forty 42-pound guns, and had, in addition, a device for discharging against an enemy attempting to board, 100 gallons of boiling water a minute! But the crowning equipment of all was a mechanism which "brandishes 300 cutlasses with the utmost regularity over her gunwales, works also an equal number of heavy iron pikes of great length, darting them from her sides with prodigious force, and withdrawing the same every quarter of a minute!"

But perhaps even such a vessel and its equipment would not have seemed as amazing and as formidable at that time as would one of the ships which are familiar commonplaces in our time, could it have been exhibited then.

The Breathing of Insects

Some interesting experiments on the respiration of insects have been made by J. Regen, as reported in *Umschau*. The insect is placed in a horizontal glass tube with a hole at the end, through which the antennæ are allowed to protrude. Through the bottom of the tube a pin passes upward and is applied with its head against the abdomen of the insect, which is the part of the body in which respiration takes place. The motions of the pin are transmitted to a lever and thence to a tracing point which traces a curve on a sheet of blackened (smoked) paper. The curve shown in the accompanying drawing was obtained with a grasshopper. It is interesting to note that the operation of breathing in insects differs from that in man and mammals generally. In man inspiration is a muscular act, while expiration follows automatically, the thorax being simply allowed to assume its relaxed position.



Instrument for graphically recording the respiration of insects.

In the case of insects, these conditions are exactly reversed, expiration being active, inspiration passive.

When carbon dioxide was introduced into the tube, the insect became unconscious and all motion ceased. If this state of affairs is allowed to continue for some time the animal dies. If, on the other hand, air is again admitted after a moderate length of time, it revives.

It was observed that in decapitated insects breathing was considerably slowed down, so that it appears that the brain has an influence upon the rate of respiration.

The Abderhalden Reaction for the Diagnosis of Disease

Communication from our special European agent.

The fundamental discoveries of sero-therapeutics made by Robert Koch twenty years before opened a new epoch in the history of medical science. Koch proved that the human as well as the animal organism reacts against invading bacteria, "xenogeneous" bodies as science calls them, by producing protective substances. The object of these protective substances is to annihilate the bacteria in the blood. Generally these substances show certain characteristics that make it easy to ascertain their presence. Thus it was found possible to recognize certain infectious diseases at an early stage by an examination of the blood. But the discovery of Robert Koch has not only shown the way to a rapid diagnosis of the nature of the illness, it has also enabled us to fight the disease with the aid of the protective, or better, annihilating substances produced by nature itself. Animals are vaccinated with the bacteria provoking some special illness; these animals sicken and form in their blood certain protective substances. The blood of these animals, impregnated with these substances, is then introduced as "serum" into the veins of human beings infected by a like disease. Thus the natural weapons of the body for fighting the illness are being artificially strengthened. For certain diseases the curative results thus obtained are positively marvelous, for instance, in the case of diphtheria, with the "serum" invented by Behring.

Thus, medical science had found entirely new ways by the methods discovered by Koch and perfected by Behring. Should it prove possible to apply the diagnosis and the treatment by serum directly to diseases, irrespective of any bacterial agents which may or may not be involved, then the whole medical science would undergo a revolution. This is the starting point of the inspired discovery of Abderhalden.

His experiments have proved that the human and the animal organisms react in the same manner as against the invasion of "xenogeneous" bodies or bacteria, also against "haemoxene" bodies, by creating "protective ferments." "Haemoxene" bodies are those substances which, while created by the organism itself, do not enter into the blood under ordinary conditions of normal health.

Every organ of the animal organism has its own particular function; in order to properly carry out this function, it is provided with a chemical and molecular constitution of its own. The liver-cells, whose functions differ entirely from those of the lung-cells, are also constructed chemically on quite a different basis. But the blood must always remain homogeneous, if it is to fulfill its life-preserving task. Therefore, the different organs must pass on to the blood the dead cells, used up by the process of life, and their own products of assimilation and dissassimilation in a chemically homogeneous form. To do so, every organ performs extremely complicated chemical decompositions, each according to its own peculiar system.

If any one organ gets out of order, such disarrangement seems to affect first of all this process of decomposition. Parts of insufficiently decomposed cells or of imperfectly decomposed products of the assimilation and dissassimilation enter the blood and disturb or even menace its functions. The organism at once sets about to produce protective ferments capable of finally decomposing the cell-constituents of the diseased organ, "digesting" them, and thus rendering them innocuous.

It is the great, the undying merit of Abderhalden to have discovered the formation of these protective ferments, and his merit is the greater because his discovery was not an accident, but the result of many years of serious and painstaking research.

The discovery made by Abderhalden proves that the organism diagnoses its own illness automatically. It remains for us to learn to understand its language. And this diagnosis has the enormous advantage of being infinitely more exact, more rapid, and more certain than all that human art can ever attain.

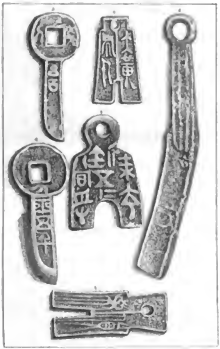
Each organ contains special ferments within its cells. These ferments are in the most subtle way attuned to the molecular constitution of the particular cell-substance of the respective organ, and show complete indifference toward the cells of other organs. Under normal conditions these cell-ferments are only found at the particular place where they have to accomplish their task, i. e., within the cell itself. As soon, however, as there appears in the blood a substance still showing the "cell-characteristics," the corresponding ferment also appears in the blood. Experiments have proved that the protective ferments can often be found in the blood only a few hours after the first disturbances in the function of the organ. The "police-service" of the organism works with perfect accuracy. These ferments are, as has been said already, extremely characteristic in their effects, decomposing only the cell-parts of the organ to which they belong. Therefore, by the methods elaborated by Abderhalden, we have the possibility of diagnosing organic disorders at their very first stage and this, as shown by experiments with chemical substances, very often after only a few days or even hours, while under ordinary circumstances, weeks and months, even years, may elapse before the effects of the disorder have grown to the proportion of pathological symptoms. An imaginary example, anticipating the expectations placed upon Abderhalden's discovery, will show this more clearly.

Someone comes to his doctor complaining of strong and continuous headaches accompanied by insomnia. The examination reveals no symptom permitting a definite diagnosis. The doctor takes a small quantity of blood from the patient and distributes it in a number of test-tubes. Into each test-tube is then put a piece from a different organ of the animal used for the control: a piece of brain matter, a piece of liver, of the lung, of the kidneys, of the heart, of the thymus and of the thyroid gland, as the patient's headaches may have the most various causes. Controlling the test-tubes twenty-four hours later it is found that lung, liver, kidneys and heart have not been altered by the serum but that the brain and the thyroid gland show signs of being decomposed. This proves that the blood of the patient contains ferments from the brain and from the thyroid gland. The presence of these ferments in the blood indicates that the functions of these two organs are disturbed, thus introducing into the blood cells insufficiently decomposed. The secretion of the thyroid gland being of extreme importance for the proper function of the brain, the positive reaction of this part of the experiment shows that the disturbances of the brain cells are caused by the thyroid gland supplying the brain insufficiently with this necessary secretion. Thus the doctor knows exactly where his treatment has to set in.

One must know the difficulties that beset the timely and correct diagnosis of disturbances of the internal organs, more especially when it is a case of functional disturbances as yet not showing any alterations of the respective organ itself, to be able to appreciate the overwhelming importance of this discovery for the curing of disease.

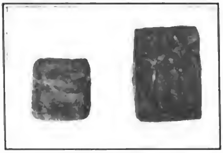
This importance accounts for the fact that medical authorities of universal repute have felt it their duty to draw particular attention to this discovery. Should the experiments that are being conducted in all the great centers of Europe prove the theory of Prof. Abderhalden to be universally valid, based as it is already on a great number of definite facts and experimental results, then medical science enters upon a new epoch and the name of the German scientist Abderhalden will have its indelible place in the golden book of humanity's greatest men.

It is too early to form any final conclusion as to the ultimate success and scope of the methods initiated by Abderhalden, but indications are exceedingly favorable in relation to a number of diseases, especially sarcoma (cancer), and certain troubles of the nervous system and brain.



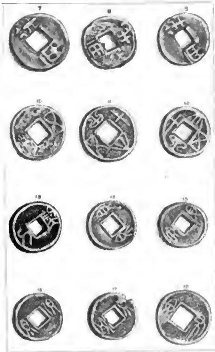
Chinese coins in the collection of Horace Fletcher, San Francisco.

1, Coin of Sung, B. C. 2257; 2, Coin of the Chau, or Chow Dynasty, B. C. 245; 3, 4, 5, and 6, Four coins of the Han Dynasty, A. D. 9.



Egyptian brick money.

Said to have been dug up in Babylonia, purchased in Constantinople in 1885 and submitted in 1898 to Mr. Hormuzd Rassam, assistant to Sir Henry Layard, who pronounced them to be genuine, very ancient, and possibly unique. They had evidently once been jeweled, and were probably taken from some sepulchre. In A. D. 1171, the Fatimite caliphs of Egypt issued similar coins of porcelain and glass, specimens of which are to be found in most of the great coin cabinets of Europe. They are mentioned in Del Mar's "History of Monetary Systems."



Chinese coins in the collection of Horace Fletcher, San Francisco.

7, Half Tael, B. C. 175, Pan Liang; 8, Another of same date; 9. Another dated B. C. 130; 10, Five Chue or Ihola, B. C. 130, Ung Chue; 11, Fifty Chue, A. D. 9, Hai Tshuen; 12 to 18, Seven coins of same period of the "cash" type.

The Evolution of Coins and Coinage Mechanisms

By Alexander Del Mar

THE oldest coins (from cuneus, a punch) are assigned by Herodotus to Lydia and by Mionnet to Persia; but if the word is intended to cover cast or hammered metallic money, then coins are 12 or 15 centuries older than the Persian darics; for we have Chinese bronze "knife" coins of Sung, 2257 B. C. inscribed "Tong King Ho," or good for gold, also numerous allusions to metallic money, not weights, but "current money with the merchant," (Genesis xxiii, 16) as the Hindu ramatenkis and siccas, Babylonian brick money, Hyksos ring money (bangs), cowries, and other very ancient testimonies.

These evidences prepare us to trace the metals from which these moneys were made.

The oldest gold mines for which we possess literary evidence are the auriferous of Hyperboria (Thibet) in Herodotus; the oldest by inference are the alluvions of India; the oldest by inscriptions and modern survey are the Bisharee alluvions of Egypt, nineteenth century B. C. A comparison of all the evidences leads to the conclusion that the knife money of China is the oldest of all moneys, the ramatenkis of India, bricks of Babylon, ring money of Egypt, and the punched coins of Asia Minor following successively, in the order of time.

Between the rude issues of Asia Minor and the most perfect coins of the Greek States is an interval of three centuries, during which all that is known, or probably ever will be known, in beautifying a steel die was achieved. So far as design is concerned, the Greek coins were simply perfect. No modern coins can compare with them in beauty.

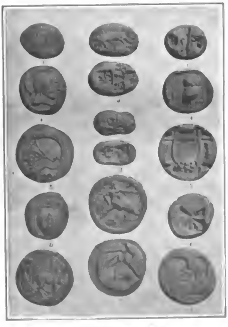
Among the early Roman coins, the ace or æs, Æ, was of cast bronze, the others were of gold, AV, for aurum, or silver, AR, for argent. Though mostly designed by Greek artists, they betray a decadence of the fine arts. The daggers of Brutus and Cap of Liberty on his silver coins are especially interesting. They were struck in the field near Philippi, where he met his fate. On the other hand, the Roman coins evince a practical improvement in the art of coinage; for the designs are surrounded by a line of dots, or a raised circle, to guard against clipping; a Greek invention, popularized by the Romans.

Roman coins of the imperial period are of the greatest historical interest. From the sad and furrowed face of Julius to the self-satisfied effigy of Domitian, extends an interval of 100 years, filled with the most noteworthy events in the history of Rome.

With the removal of the capital to Byzantium (Constantinople) began that rapid decline in the arts characterized by the "Dark Ages" and feudal system; the coinage faithfully reflecting it: for the arts cannot flourish in serfdom or slavery.

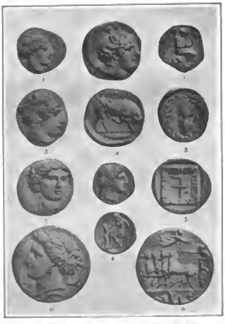
This decadent period lasted until the Arabian Renaissance of the twelfth and Italian Renaissance of the fourteenth century afforded, through the agency of commerce, encouragement to the arts.

The discovery of America and its influence in ameliorating the social condition of Europe is the greatest event in the history of the world. In little more than



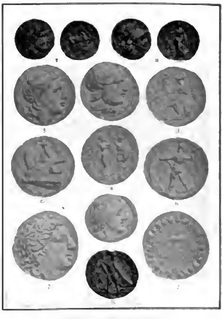
Early Greek coins, B. C.

1, Ionia (El.); 2, Ephesus? (El.); 3, Croesus (A. V.); 4, Athens (A. R.); 5, Calymna (A. R.); 6, Aegina (A. R.); 7, Tarentum (A. R.); 8, Syracuse (A. R.).



Greek coins. Five periods, B. C. 480-400.

1, Terina (A. R.); 2, Thurium (A. R.); 3, Elis (A. R.); 4, Tarentum (A. V.); 5, Amphipolis (A. R.); 6, Syracuse (A. R.).



Historical Greek coins.

1, Philip of Macedon; 2, Alexander the Great; 3, Lysimachus of Thrace; 4, Seleucus I of Syria; 5, Ptolemy I; 6, Demetrius Poliorcetes of Macedon; 7, Mithradates.

Roman Republican coins.

1, Denarius (A. R.); 2. As (A. E.); 3. Sulla (A. V.); 4. Julius Cæsar (A. V.); 5, M. Antony and M. Lepidus (A. V.); 6, Octavian (A. R.); 7, Sextus Pompey, Pompey the Great and Caeius Pompey (A. V.); 8, Brutus (A. R.).

The twelve Cæsars.

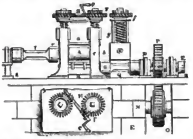
1, Julius Cæsar; 2, Augustus; 3, Tiberius; 4, Caligula; 5. Claudius; 6, Nero; 7. Galba; 8. Otho; 9. Vitellius; 10. Vespasian; 11. Titus; 12. Domitian.

Anglo-Saxon coins.

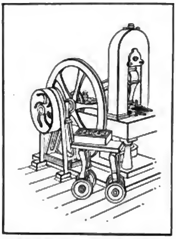
1, VIII Century Sceat; 2, Offa of Mercia; 3. Aethelberht of East Anglia; 4, Wigmund, Archbishop of York (gold); 5, Alfred of Wessex; 6, Halfdan; 7, Olaf Quaran; 8, Edward the Elder; 9. Aethelred II; 10, Edward the Confessor.

a single century, 1540-1650, were made nearly all the great discoveries in science and art which afford the basis of our existing industries, scientific attainments, and mechanical inventions. Here again the coinage reflects the revolution. Compare the pennies of the Normans with the Italian effigies of Mary and Elizabeth; or the groats of Henry VI with the guineas of Charles II.

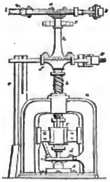
This brings us from coins to coinage; from the fine arts to mechanisms. Leaving cast coins, and brick and ring moneys, out of view, the ancient method of making a coin was to hammer out a thin plate of metal, cut it into circular disks with the shears, and strike it with a steel punch, incused with a design; the blow



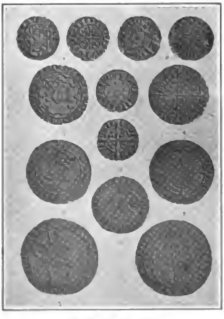
Rolling mill for "flatting" metal for coining.



Embossing press for stamping the designs on coins.

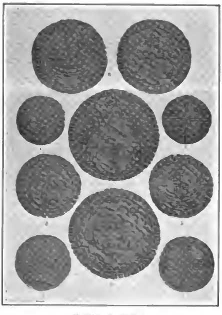


Press for punching coin blanks.



English silver coins.

1, William I, penny; 2, Henry I, penny; 3, Edward I, penny; 4, Henry VI, groat; 5, Henry VII, shilling; 6, Elizabeth, sixpence; 7, Charles I, half crown.



English gold coins.

1, Henry III, gold penny; 2, Edward III, noble; 3, Henry VI, angel; 4, Henry VII, sovereign; 5, Charles II, guinea.

English historical medals.

1, Mary, Queen of Scots, by Primavera; 2, Elizabeth, Badge—Defeat of Armada.

being delivered by hand, in much the same way that we would now put a punch mark upon a metal plate. The coin was then finished with a file. The next improvements were to roll the metal between two small cylinders, so as to produce a plate of uniform thickness, and to cut it into disks with a punch. At this point invention stopped and retrograded for practically a thousand years, during which time the population of Europe declined from 120 to 40 millions, and commerce retrograded to barter, or to payments in kind.

The metallic plunder of America was the tremendous lever that converted the decay of Europe into an era of progress. In the fifteenth century a skilled coiner, of whom there were but few, might be able to turn out by hand 50 or 60 coins a day; a result totally inadequate to cope with the vast quantity of treasure, chiefly silver, that shortly began to arrive from America. To multiply coiners was to multiply forgers; and thus the coining machine became a necessity of State. A laminating mill and screw coining press was invented in Italy, 1547; Spain, 1548; France, 1553; England, 1561, reign of Elizabeth.

After several trials and abandonments the mill and press were established permanently under Charles II, whose golden guineas, struck in 1662, were the first regular issues of machine coins made north of the Channel.

The laminating machine is sufficiently explained in the illustration showing the rolling mill (page 121), where a sheet of metal is made to pass between rollers *A* and *B*, which reduce it to a uniform thickness. Circular disks, exact size of the coin to be made, are then punched out by the machine.

Finally the disks are submitted to a double punch, the upper one being a steel die incused with the obverse, and the lower one incused with the reverse of the coin to be produced. When subjected to this double process, with a pressure of 50 to 75 tons, the inert disks, no matter what their commercial value, are transformed into money, with the legal value conferred upon them by law. The double punch constitutes the seat of the State; and it is that, and the mint law behind it, which converts metal into coins and coins into the "dollars" or other monetary denominations described in the legal-tender law.

The Determination of Plant Relationship by Means of Serum

A Means of Investigating Origins by a Comparison of Albumens

The problem of every system of classification, whether zoological or botanical, is such arrangement of the organisms that their historical development from their origin down shall be presented as clearly as possible. The classification of animals and plants in a natural system is to some degree the indication of the ratio of relationship of the individual species to common ancestors. As, however, all judgments in regard to the construction of a system of classification rest upon subjective perception of similarity and disparity between the objects contemplated, various attempts have been made of late to use similarities other than those formerly held to be important as a basis for the natural system, or as the reason for changes in it, or even for overthrowing it. In any case its divisions are capable of change, and it is only the older botanists who looked upon the system as a fixed series of pigeon-holes for the accommodation of their discoveries in the vegetable kingdom. This elder generation, though, has passed away. The history of evolution teaches that there is a progressive differentiation. Far greater uncertainty exists, however, in the classification of the individual groups, because consanguinity cannot always be traced with certainty on account of morphological conditions, and so there is no doubt that even to-day we are still far from being able to regard our "natural" systems as final.

The necessity of making every possible effort to place systematology, especially that of the higher plants, on a better basis has led to investigations with the aid of the serum diagnosis. In discussing in the *Umschau* this method of determining the classification of plants, Dr. Kurt Gohlke says:

"The methods of this diagnosis by means of serum have become very important of late years, for the most widely separated branches of science. Uhlenhuth has been able to prove not only that the blood of one animal can be distinguished from that of another by the aid of serum reactions, but also that the relationships of the different kinds of blood can be determined. Especially interesting are the results which Uhlenhuth, Wassermann, and Stern were able to prove concerning the connection between human blood and that of the various species of apes, thus establishing 'consanguinity' by means of sero-biological methods.

"Most interesting for the natural sciences was the proof offered by Kowarski that vegetable albumen also could be determined by means of a diagnosis with serum. Various experiments were made on this point, one of which was that of Magnus and Friedenthal, who were able to show a relationship between truffles and yeast fungus."

Any discussion of a natural relationship presupposes, however, a preliminary investigation as to whether this relationship of the albumens is to be regarded as equivalent to the natural relationship. When we consider the important part played by chemical processes in the life of every organism, it can probably be assumed with certainty that the close or distant relationship between two organisms in the great ancestral stock of the organic kingdom will also be evident in their chemical properties. This natural relationship must also of course be evidenced in the structure of the highly concentrated albumen which is so closely connected with the vital functions. The composition of these albuminous substances is not known. At any rate it is not possible, at least by chemical means, to determine them so exactly that this determination would suffice for the purposes of classification. It has, however, become possible, as has been said before, to secure a differentiation of albumens by the aid of serological investigation.

"Before, however, I enter into the particulars of the various methods in question," continues Dr. Gohlke in pursuing his subject, "I should mention that the utility of these methods for special botanical purposes had to be proved. The proving of this utility became absolutely necessary after the publication of the experiments previously made, some of which were decidedly fragmentary and were not undertaken for the purpose of systematic grouping in families, while others yielded contradictory results.

"To this end, four methods were tried, namely, precipitation, the binding of the complement (Wassermann's reaction), anaphylaxis, and conglutination."

For the botanist probably anaphylaxis (hypersensitiveness) had to be excluded as a matter of course. The method of using it is the following: "If foreign albumen is introduced, as by inoculation, into the body of a warm-blooded animal, there is developed after awhile, and after the introduction of a certain amount of the inoculating material, a peculiar sensitiveness. This hypersensitiveness is evidenced in this way: that the animal thus treated reacts with violent symptoms of illness, and often dies in a few minutes if inoculated again with the same solution of albumen, even when this contains no poison. The condition called anaphylaxis has, therefore, a strictly specific effect, that is, rabbits previously treated with horse serum are only hypersensitive to this and not to goat or bovine serum. Relationships, though, can be recognized."

As the albuminous solutions with which botany is concerned are obtained almost entirely from the seed of plants, and as the solutions vary greatly in the amount of albumen they contain, each depending on the albuminous content of the respective seed, an exact judgment as to the experiments made by anaphylaxis is, therefore, difficult. Any positive judgment becomes impossible when it is remembered that a large amount of other substances, some poisonous (as alkaloids) are contained in the solution, which substances must be injurious to the animal. Besides, the undue proportion of deaths among the animals used for the experiments condemns the use of the method in proving relationships in a botanical classification.

"Without going into the method of binding the complement, which is that of Wassermann's reaction used in the investigation of syphilis," says our writer further, "I wish to reject it as also unsuitable for the present purpose. The results of this method are extremely exact and clearly defined, but are too specific for the end in view. It is easy by the aid of this method to determine the albumen (antigen) used for the inoculation, the reaction also appears if the albumen belongs to another closely allied species, but it fails for more distant relationships. For a system of classification, though, it is important to be able to prove very distant relationships, consequently to obtain a remote reaction."

The two other methods, precipitation and conglutination, are well suited for obtaining reactions showing connections. Precipitation is extremely simple, and requires only an antigen and an immune serum produced by this antigen. This immune serum is obtained as follows: An albuminous solution (as an extract of the albumen of beans) is injected into the circulation of a rabbit. After a number of injections, when the rabbit's blood is drawn off and coagulates, the serum which separates forms the immune serum. This immune serum has the characteristic that in clearly defined gradations of dilution up to a certain degree it gives a precipitate with the antigen used for injection, that is with the bean albumen, but it does not give a precipitate with an albuminous solution of other origin. This assertion, however, cannot be pushed too far. This specific reaction appears only when the albuminous solutions, that is, the albuminous solution used for injection and the second albuminous solution, do not come from related seeds. Thus, for instance, an immune serum produced by means of a papilionaceous plant, the lentil, reacts upon all other papilionaceous plants and further upon the related rose and crowfoot families, but, on the other hand, it does not affect a single plant of another more distantly allied family (as the grasses). The first experiments for a reaction showing relationships were made by this method. Besides its simplicity, precipitation has for botany another great advantage over other methods, namely, it brings to view not only connections with other families of the same series far beyond the family with which it starts, but what is still more important it shows connections with other series also.

"Conglutination," according to Dr. Gohlke, as he explains how to use the immune serum in testing the albumen of seeds, "is somewhat more difficult in its technical details, as when it is employed, the serum of a ruminant (for instance, bovine serum) is used. If in the method by precipitation we had to do with the graduated dilution of the albuminous solution in various test tubes (1 to 200, 1 to 400, etc., up to 1 to 50,000), in the method by conglutination the amount of albumen in the extract is constant in all the test tubes (the dilution might be 1 to 200), and the variation is only in the amount of immune serum that is added to it. The proportion of serum in this method is exceedingly small (0.08, 0.02, 0.01, 0.005 cubic centimeter in test tubes Nos. 1 to 4, while in the precipitation method each glass receives 0.1 cubic centimeter). In the conglutination method the extract and the immune serum are combined at 37 degrees in two hours in the incubator, that is, the extract is sensitized. After this period of time, fresh bovine serum is added in the proportion of 0.1 cubic centimeter for each tube. There then appears in those tubes where a large amount of the immune serum is present a clearly evident conglutination, that is, a flocculent precipitation, which is entirely different from the deposit of the precipitation method. This characteristic clumping rests on this fact, that bovine serum contains some substances which are called conglutinins and which produce conglutinations. The advantages of this method consist in the ideal sensitiveness which essentially exceeds that obtained by precipitation, and in the small amount of immune serum it is, on this account, necessary to use. This permits hundreds of experiments to be made in all directions in the vegetable kingdom from one original immune serum. A necessary condition is, however, that the immune serum should be of highest potency."

This brings us to a very important point. The amount of albumen contained in the extracts of albumen gained from the seed of plants varies so greatly that it is much more difficult to immunize the rabbit than it is to immunize blood in analogous experiments in hygiene or zoology.

The seeds in Dr. Gohlke's experiments were crushed to a very fine meal in mortars or in the mill, which work demanded naturally extreme cleanliness. The meal was then mixed in definite proportions with a solution of common salt, and some time was allowed for extraction. The solutions of albumen thus obtained were cloudy and were filtered until clear.

There appeared during this process the collateral phenomena characteristic of vegetable seed. Various substances were found which are supposably injurious to the animal if injected, and which would even cause death. Although the most varied experiments were made for the removal of these injurious substances, these experiments were not always successful in getting rid of all of them. Consequently, in discussing the utility of the albumens to be used in the experiment, a preliminary investigation as to whether these injurious substances are present in the albumen must be assumed. On this account the preparation of the extract varies according to the specific character of each seed.

Occasionally a potent immune serum is obtained after three or four injections, 10 cubic centimeters being used for each injection. There are, though, cases in which no immunity was attained after frequent injections. The reason for this is either in a distinctive peculiarity of the animal, for Uhlenhuth mentions that, for instance, of ten animals treated at the same time with albumen only one yields a potent immune serum, or else the difficulty arises from too small a content of albumen in the extract. This latter trouble appears with relative frequency, because many seeds contain hardly any discernible albumen, as the very small seeds of the willow.

To get the immune serum the animal is bled, the coagulated blood is centrifuged, and the serum thus obtained is preserved.

"Whoever after this undertakes to make researches as to relationships by means of serum reactions," pursues the author, "must constantly bear in mind that there are many pitfalls which can only be avoided by the greatest caution. But the person who has worked by these methods for some time soon gains an exact knowledge of the reactions and certainty in judging them, so that he can enter upon the researches with absolute confidence. This confidence is further strengthened by experiments with seeds of unknown origin and control experiments both with normal rabbit serum, and pure extract, etc.

"Diagnosis by means of serum has proved its utility both for methods and for the purposes of classification. A large number of families have already been investigated as to their systematic position, and further researches are being made under Prof. Dr. Mez in the Botanical Institute of the University of Königsberg. It would take us too far to give a detailed report of the very interesting results."

The author then refers to some books by himself and others on the subject, all published in 1913. His own work is on "The Utility of Serum Diagnosis for Proving Doubtful Relationships in the Vegetable Kingdom;" one by Gohlke and Mez is "Physiologico-Systematic Researches upon the Relationships of the Anglo-Spermæ;" and by Lange, "Sero-Diagnostic Researches upon the Relationship within the Plant-Group of Ranunculaceæ."

It should be mentioned that in no case have the researches made up to now resulted in a contradiction of the determinations which have been deduced from the forms of plants. On the contrary, serum diagnosis offers a method by which we can advance in the difficult field of the historical investigation of origins. It is true that a relationship of the plants is not directly proved, yet the determining of a connection between the albumens gives an important indication of relationship. This is a great advance which yields valuable conclusions for the history of the main stock, and thus the importance of this method for the development of science is made plain. Consequently the value of serum diagnosis for the proof especially of doubtful relationships in the vegetable kingdom cannot fail of recognition.

The Meeting of the British Association in Australia

By the English Correspondent of the Scientific American

The eighty-fourth meeting of the British Association, which has just commenced, promises to be a great success. The Commonwealth government made a subsidy of $75,000 in aid of the expenses, besides publishing a Federal Handbook of 600 pages for gratuitous distribution to the visitors, some 350 in number. In addition, the premiers of the various states have secured free railway facilities, and have taken an active part in promoting schemes of reception and hospitality.

The holding of the meeting in Australia makes, naturally, a strong appeal to Englishmen. One of the greatest of British discoverers, Capt. James Cook, whom tardily enough, we have recently commemorated by a statue, added Australia to England's possessions, and its colonization was the ultimate result. In 1788 the first settlement was formed, and thirteen years afterward Capt. Matthew Flinders began his exploration of the shores of the island, "undertaken for the purpose of completing the discovery of that vast country," and carried out in H.M.S. "Investigator." The original name was Terra Australis, used by the Dutch themselves until some time after Tasman's second voyage in 1644, subsequently displaced, however, by the term New Holland, though this was applied to part only of the region. Flinders remarks that so soon as New Holland and New South Wales were known to form one land, a general name was advisable, and therefore he ventured upon the readoption of the original Terra Australis. "Had I," he adds, "permitted myself any innovation, it would have been to convert it into Australia, as being more agreeable to the ear, and an assimilation to the names of the other great portions of the earth."

Reaching Melbourne on August 13th, Prof. William Bateson, F.R.S., the new president, was to deliver on the following day his address (in part) to the association. It refers to heredity and variation as factors in organic evolution, in the light of, and along the lines of, the discoveries made many years ago by Gregor Mendel of Brünn, and now embraced by the term Mendelism. After a stay of six days the visitors proceed to Sydney, and in that city, on August 20th, the concluding portion of the president's address will be given. Following another stay of six days, the association moves on to Brisbane, where the remainder of the official programme will be carried out, concluding on August 31st. In the course of the itinerary thus outlined a series of public lectures will be delivered (beginning at Adelaide on the subjects: "Saving and Spending," (Prof. Gonner); "Brown Earth and Bright Sunshine," (Prof. B. Moore, F.R.S.); "The Making of a Big Gun," (Dr. W. Rosenhain, F.R.S.); "Comets," (Prof. H. H. Turner, F.R.S.); "Clocks," (Sir Henry Cunynghame); and "The Decorative Art of Papua," (Dr. A. C. Haddon, F.R.S.).

During the tour, the presidents of sections will deliver the customary addresses relative to the respective branches of science which they represent. Prof. F. T. Trouton, F.R.S., of University College, London (mathematical and physical science section), is detained at home through illness, and his presidential address will be read by a colleague. Sir Ernest Rutherford, F.R.S., opens a discussion on the structure of atoms and molecules, and the Astronomer Royal reads a paper on the distribution in space of the stars near the north pole. Prof. W. J. Pope, F.R.S., of Cambridge University (chemistry section), expounds new researches in crystallography. Sir Thomas Holland, K.C.I.E., F.R.S., of Manchester University (geology section), following the delivery of his presidential address will open a discussion on the physiography of arid lands. Prof. Arthur Dendy, F.R.S., of King's College, London (zoology section), is to discourse on evolution; and there will be a discussion on mimicry in Australian insects. Sir Charles Lucas, K.C.B. (geography section), gives an address on man as a geographical agency. Many interesting papers are before the section, including one on Central Australia and its possibilities. Prof. E. C. K. Gonner, of Liverpool University (economic science and statistics section), will invite attention to three papers on town planning; and Sir Henry Cunynghame will discuss the effects of monopoly on prices. Prof. E. G. Coker, of Finsbury College (engineering section), will deal with stress distribution. Sir Everard im Thurn, K.C.M.G. (anthropology section), is to discourse on primitive peoples in Australasia; and there will be a paper by Prof. G. Elliot Smith, F.R.S., of Manchester University, on the origin and spread of certain customs and inventions. Prof. B. Moore, F.R.S., of Liverpool University (physiology section), takes the subject of the value of research in the development of national health. Prof. E. O. Bower, F.R.S., of Glasgow University (botany section), will discuss the Australian flora, its types, and adaptations. Miss E. R. Saunders contributes a paper on the double stock, detailing its history and behavior during cultivation. Prof. John Perry, F.R.S. (educational science section), discourses on the relations of university and state, and Prof. H. E. Armstrong, F.R.S., recapitulates before this section his views on science and education. Dr. A. D. Hall, F.R.S. (agriculture section), has chosen the subject of land reclamation and cultivation. There will be several contributions on wheat growing and wheat breeding in Australia.

In addition to the foregoing sectional proceedings, joint discussions have been arranged on wireless telegraphy, to be opened by Sir Oliver Lodge; and on the past and present relations of Antarctica in their biological, geographical, and geological aspects, to be introduced by Sir Douglas Mawson, the Antarctic explorer.

"Napier's Bones"*

By Prof. George N. Gibson

In popular estimation it is perhaps the phrase "Napier's Bones" that most readily recalls his name. Though the device is now of little practical importance, it is at least an instance of Napier's faculty of combining simple practical applications with great theoretical insight. The Bones are described, though not under that name in the book: "Rabdologiae, seu Numerationis per Virgulas Libri Duo: Cum Appendice de expeditissimo Multiplicationis Promptuario. Quibus accessit et Arithmeticae Localis Liber Unus." (Edinburgh: Andrew Hart, 1617.) The book is dedicated to Alexander Seton, Earl of Dunfermline, and in the dedication Napier states that he was induced to publish a description of the construction and use of the "numbering rods" (that is, of the "bones") because many of his friends to whom he had shown them were so pleased with them that the rods were already almost common and were even being carried to foreign countries.

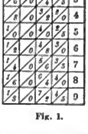


Fig. 1.

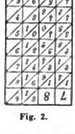


Fig. 2.

Mr. Glaisher, in his article on Napier in the "Encyclopædia Britannica," gives a clear account of the numbering rods or bones, and as I cannot improve upon it I transcribe it here. The bones as described by Mr. Glaisher are slightly different from those that appear in the "Rabdologia" but represent a common type.

The principle of "Napier's Bones" may be easily explained by imagining ten rectangular slips of cardboard, each divided into nine squares. In the top squares of the slips the ten digits are written, and each slip contains in its nine squares the first nine multiples of the digit which appears in the top square. With the exception of the top square, every square is divided into parts by a diagonal, the units being written on one side and the tens on the other, so that when a multiple consists of two figures they are separated by the diagonal. Fig. 1 shows the slips corresponding to the numbers 2, 0, 8, 5, placed side by side in contact with one another, and next to them is placed another slip containing, in squares without diagonals, the first nine digits. The slips thus placed in contact give the multiples of the number 2085, the digits in each parallelogram being added together; for example, corresponding to the number 6 on the right hand slip we have 0, 8 + 3, 0 + 4, 2, 1; whence we find 0, 1, 5, 2, 1 as the digits, written backward, of 6 × 2085. The use of the slips for the purpose of multiplication is now evident; thus, to multiply 2,085 by 736 we take out in this manner the multiples corresponding to 6, 3, 7 and set down the digits as they are obtained, from right to left, shifting them back one place and adding up the columns as in ordinary multiplication, viz., the figures as written down are:

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  12510
  6255
14595
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1534560
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Napier's rods or bones consist of ten oblong pieces of wood or other material with square ends. Each of the four faces of each rod contains multiples of one of the nine digits, and is similar to one of the slips just described, the first rod containing the multiples of 0, 1, 9, 8, the second of 0, 2, 9, 7, the third of 0, 3, 9, 6, the fourth of 0, 4, 9, 5, the fifth of 1, 2, 8, 7, the sixth of 1, 3, 8, 6, the seventh of 1, 4, 8, 5, the eighth of 2, 3, 7, 6, the ninth of 2, 4, 7, 5, and the tenth of 3, 4, 6, 5. Each rod, therefore, contains on two of its faces multiples of digits which are complementary to those on the other two faces; and the multiples of a digit and its complement are reversed in position. The arrangements of the numbers on the rods will be evident from Fig. 2, which represents the four faces of the fifth bar. The set of ten rods is thus equivalent to four sets of slips as described above.

To the above extracts from Mr. Glaisher's article I may add that the bones had a great vogue, and were very extensively used for several years after Napier's death. The "Rabdologia" was translated into Italian and Dutch, and the Latin edition was republished at Leyden. In "The Art of Numbring By Speaking-Rods: Vulgarly termed 'Nepier's Bones,'" which was published at London, in 1667, William Leybourn (who is denoted on the title page simply as W. L.) gives a description of the rods, with examples of their use in multiplication, division, and the extraction of square and cube roots.

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[*] Extract from a paper read before the Royal Philosophical Society of Glasgow.

A New Safety Device for Coal Mines is described in a report from the American consul at Dunfermline, Scotland, its purpose being to prevent the fall of the cage in case the rope of the latter breaks. Two extra chains come from the base of the rope, and these running down the sides of the cage are fastened to four pieces of strong wood that project from the four bottom corners of the cage. While the weight of the cage rests upon these pieces of wood the latter are drawn inside the cage, but when relieved of this weight, by the breaking of the rope, they are spread outward by springs and catch the buntings with which the sides of the shaft are faced, and the cage is brought to a standstill within a maximum space of four feet.

The Total Solar Eclipse, of August 21st

By William J. S. Lockyer

Owing to the great strides made in the study of the physics of the sun, the importance of the occurrence of a total eclipse of the sun is not so great as it was toward the latter end of last century. Nevertheless, there are still some problems to be solved, the data for which can only be obtained on these occasions, thus necessitating the organization and dispatching of observers to several stations lying on the path traced out by the cone of the moon's shadow as it sweeps over the earth's surface.

The present year presented us with a total eclipse as near at home as that which occurred in the year 1896; in fact, these eclipses belong to the same family, and it is likely that the event was as well attended by both amateur and professional astronomers as was its forerunner. It is hoped, however, that weather conditions were more favorable for successful observation, for it will be remembered that on the last occasion the only party that was fortunate enough to come home with results was that which took up a station in Nova Zembla.

European observers were especially favored by the position of the path of the moon's shadow, because the greater portion of the accessible track cuts Europe diagonally through its central portion. Thus, with comparatively little journeying, very favorable stations for observation were reached.

The accompanying illustration (Fig. 1) shows the general position of the line of central eclipse. It will be seen that the eclipse began at a point situated in north latitude about 71½ degrees and ended in a latitude a little greater than 23½ degrees. The moon's shadow first struck the earth in far north Canada, passing a little south of the Parry Islands, and pursuing its course just above Baffin's Bay. There it entered Greenland, and swept across this sparsely inhabited region, emerging into the Arctic Ocean. Taking a southeasterly trend, it entered Norway near the island of Vega, and passed out of Sweden near Hernösand, and then crossed the Gulf of Bothnia and the Baltic Sea. The track then entered Russia at Riga, and passed near Minsk, Kief, and the eastern part of the Crimea, crossing the Black Sea and reaching the opposite coast at Trebizond. It then traversed eastern Turkey and western Persia, and terminated its course on the northwest coast of India.

There is little doubt that the first portion of the eclipse track—that is, the part that crossed the islands north of Canada and Greenland—was not occupied by special observers. From Norway southeastward the case will be different, for there the sun was at a useful altitude and the eclipse of long duration. On the west coast of Norway the sun had an altitude of a little over 35 degrees, and the duration about 126 seconds. On the east coast of Sweden the altitude was more than 36.5 degrees, and the duration 128 seconds. In the region about the Gulf of Riga the sun's altitude was about 38.5 degrees, and the duration 133 seconds. By the time the Crimea is reached the altitude was somewhat reduced, namely, 36 degrees 40 minutes, and the duration diminished to 129 seconds. An excellent large-scale chart of the whole track of the eclipse across Europe accompanies Count de la Baume Pluvinel's article which appeared in the March number of the *Bulletin de la Société Astronomique de France*, and this was valuable to those who wished to take up a suitable position on the track. Those who proceeded to Norwegian stations found useful data published recently in the *Observatory* by Prof. H. Geelmuyden. There it is stated that among stopping places for the ordinary coast steamers, going out from Bergen or Trondhjem, may be named Sannessjöen, situated on the north end of the Alsten Island, from which stations near the central line will be easily accessible, either on the same island or (by motorboat or local steamers) on some other islands toward the northwest. From Mosjöen, situated at the end of the deep Vefsen Fjord, stations near the central line in the Vefsen Valley may be reached by carriage. Brönnö is a stopping place not far from the southern limit, and Bodö is a little outside the northern limit. Details concerning the path of the shadow track across Turkey and Persia and the accessible places for forming camps in these countries were described in these columns (No. 1998, April 18th), so that further reference to these regions becomes unnecessary.

With regard to the weather conditions the probability of fine weather seems to increase the farther east along the track the station is taken up. According to the information that is to hand, most of the main official expeditions were to be located along the Russian portion of the line, where the good weather chances are more promising, but this did not deter others from occupying Norwegian or Swedish stations, for the more scattered the observers are the more chance there is of some results being secured.

As to the actual expeditions that were projected, the following statements may be made, and the accompanying map (Fig. 2) will help to indicate the positions of the stations which were proposed. Dealing first with the British parties, the joint permanent eclipse committee of the Royal and Royal Astronomical Societies was to send out five observers. Three of these observers, namely, Prof. Fowler, Mr. W. E. Curtis, and Major Hills, were to be stationed near Kief in Russia, and undertake the photography of the spectrum of the chromosphere during the partial phases, and a grating giving much higher resolving power than any previously employed during an eclipse was to be used. Fathers Cortie and O'Connor were being sent to Hernösand in Sweden to undertake direct photographs of the corona and photographs of the spectrum of the corona with special regard to the yellow and red regions. They were to be accompanied by Messrs. J. J. Atkinson and G. J. Gibbs as volunteer helpers.

From the Royal Observatory, Greenwich, two observers, Messrs. Jones and Davidson, took up their station at Minsk, in Russia. The programme of this party consisted in securing large-scale photographs of the corona, the spectrum of the corona and chromosphere, more especially in the ultra-violet region, and photographs of the corona through "mercury-green" glass for investigation of the distribution of "coronium." Near Feodosia, in the Crimea, the party from the Solar Physics Observatory, at Cambridge, namely, Prof. Newall, Mr. Stratton, and Mr. C. P. Butler, were located. The work undertaken included small- and large-scale direct photographs of the corona for extensions and details, respectively, objective grating photographs of the chromosphere for comparison with the slit spectra taken by Prof. Fowler's party, and lastly, polariscopic observations.

Feodosia was to be the observing station of two German expeditions, namely, one from the Astrophysical Observatory at Potsdam, and a second from the Royal Observatory in Neubabelsberg, near Berlin. Near Feodosia, at Stary Krym, an expedition from the Hamburg Observatory in Bergedorf was to take up its position. The programme of the work to be undertaken by this expedition, kindly communicated by the director, Prof. R. Schorr, included photographs of the corona with telescopes of focal lengths of 4, 10, 20, and 40 meters, with and without screens, a search for intermercurial planets, and photographs of the spectra of the chromosphere and corona.

In addition to the above, Prof. Miethe, of the photochemical laboratory of the Technical High School in Berlin, proposed going to Sannessjöen, Alsten Island, in Norway, and it is quite possible that parties from other German observatories added to the number of expeditions.

Feodosia was also the selected spot for three French missions, details about which have been kindly communicated by Count de la Baume Pluvinel. Count de la Baume Pluvinel himself was to lead a private expedition, with Messrs. Senouque and Rougier as his assistants. Their instrumental equipment consisting of a two-mirror coelostat worked in conjunction with objectives of 12 and 3 meters for the photography of the corona. Two slit spectroscopes and two prismatic cameras with flint and quartz prisms were also to be used, and measures were to be made of the intrinsic brightness of different portions of the corona.

A second expedition was to set out from the Nice Observatory under the direction of M. H. Chrétien. M. Chrétien was to be accompanied by M. Lagrula, and they expected to take up a position at Feodosia. Their main instrument was to be a coelostat with two mirrors, one of which was to feed an objective of 6 meters focal length, for securing photographs of the partial phases and of the corona; the other to supply light to a slit spectroscope for the study of the rotation of the corona. M. Chrétien proposed also to make photometric measures during the partial phases. M. Jekhowsky ex-

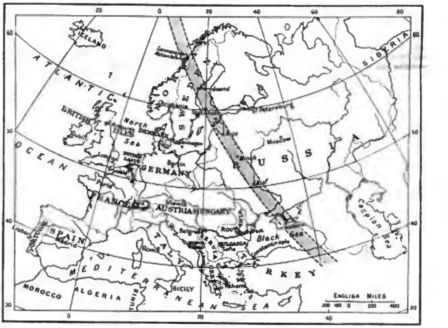

Fig. 2.—Map showing path of the shadow track.

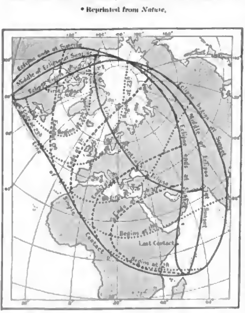

Fig. 1.—Chart showing central line of eclipse.

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* Reprinted from *Nature*.

pected to join this party, and use a concave grating of 6 inches diameter and 7 meters radius of curvature for the study of the spectrum of the chromosphere in the ultra-violet.

M. Salet, of the Paris Observatory, was to go privately to Feodosia, taking both an equatorial and a coelostat, and his chief endeavor was to be the photographic study of the polarization of the light of the corona.

Feodosia was also the station that Dr. Perrine expected to observe from; and of the expedition being organized by the Lick Observatory under Prof. W. W. Campbell, one section was to proceed to Kief, while the other occupied Feodosia. A Russian party under Dr. Donitch also took up quarters at the latter place.

While most of the expeditions were concentrating at Feodosia, it is hoped that other intending observers took up positions farther north. No doubt several amateurs, both British and foreign, also completed their plans for the event.

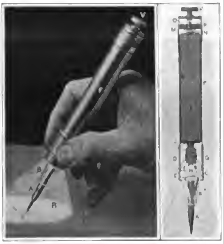
It is interesting to note that while a total solar eclipse does not offer very much scope for the use of color photography, yet several attempts were to be made with small instruments. Writing from the Nikolai chief observatory at Pulkovo, Prof. Backlund (*Astr. Nach.*, No. 4740) states that after a conference with the Minister of Finance, every facility would be offered by the Government to further the interests of the various expeditions proceeding to Russia, and that all instruments would be customs free provided observers return with them.

A Pencil for Writing in the Dark

Our illustration, which is derived from *La Locomotion*, shows a rather ingenious little device, a pencil for writing in the dark. The half-tone engraving shows the general appearance of the pencil in use, while the line cut on the right displays some of the details of the inner mechanism. The source of electricity is a small cylindrical dry cell with one pole insulated. The other pole, as is customary in such cases, is formed by the metallic container of the cell itself, which, to prevent any possible short-circuiting, is inclosed in a paper sheath. The body of the pencil is formed of a nickel-plated tube, closed at each end by a plug. The lower portion of this serves as a support for the pencil head, which holds the lead. Our illustration shows this head screwed to a small glass cone, which itself is held in place by a ring. Within the lower plug and screwed upon the main tube in an enlargement formed in a reflector, a small electric lamp is placed. This is of the usual Edison type, with screw socket.

The upper plug is also quite simple. It contains a disk of insulated fiber, pierced by a stud serving as a support for a coil spring. Above this is a screw provided with a milled head, which, upon screwing down, causes the stud and spring to communicate with the body of the apparatus.

After unscrewing the upper plug a small cell can be introduced, with its insulated pole following. This pole, in operation, is in contact with the corresponding pole of the lamp. The upper plug is now screwed into place, the milled head being unscrewed to its limit. The spring presses upon the container of the cell, holding it in place, but being insulated it cannot close the circuit. If now the milled head is screwed in, a circuit is established through the following points: first pole of the lamp, first pole of the cell, second pole of the cell, spring, screw, second pole of the lamp. Thus the circuit is completed and the current passes through the lamp and lights it up. The lower plug supporting the pencil head can very easily be drawn in, and the little pencil can also be converted very readily into a pocket torch, by substituting another lamp and cell, which can be done in a few seconds.



A, point; B, glass cone; C, adjusting screw; E, cap; F, body; G, reflector; H, lamp; K, dry-cell; L, contact; N, spring; O, contact plug; V, set screw.

This little instrument should prove something more than an interesting toy; it seems to be destined to fulfill a definite and useful function.

New Synthetic Coal Gas

A NEW lighting gas has been prepared which is claimed to be much less toxic than water gas or air gas, and yet possessing a calorific power approximating to that of coal gas, and, therefore, far greater than that of water gas or air gas. The new gas may be obtained from coal, from coke, or from water gas. When coal is used, this is first mixed with lime, and distilled at 900 to 950 deg. Cent. A current of steam is then introduced over the coke so produced, maintained at 900 to 1,000 deg. Cent. The total yield of gas, freed from carbon dioxide, is about 200 cubic meters of gas from 100 kilos of coal. It contains 70 to 78 per cent of hydrogen, 15 to 20 per cent of methane, and 5 to 10 per cent of carbon monoxide. By regulating the reaction, the amount of carbon monoxide may be reduced to practically nil. The amount of ammonia recovered as a by-product is more than four times that obtained from the same coal by the ordinary methods of distillation, and the volume of lighting gas is eight to ten times greater. The whole of the nitrogen present in the coal is converted into ammonia.—*Comptes rend.*

Driving Away Mosquitoes

CLOSED wells and cisterns are favorite places for mosquitoes to deposit their eggs, and for the purpose of driving them away the use of naphthalin has been suggested. Naphthalin, however, imparts an unpleasant taste and odor to drinking water, so instead of sprinkling it on the surface of the water, after the manner of using oil for the purpose of ridding the water of mosquito and gnat larvæ, a good plan is to suspend a bag containing naphthalin over the water. The readily volatilized substance will charge the air in any confined space and drive away the female mosquito that selects this place for her eggs. The same method might be effectively adopted for the protection of dark and damp places about houses. Experiments have shown that naphthalin vapor resulting from natural evaporation is fatal to larvæ in water as well as to the adult *Culex pipiens*.

A Substitute for Platinum

SO GREAT is the demand for platinum, for use in electrical apparatus, that many efforts have been made to devise some substitute that can take its place and be produced at a moderate price. A recently patented substitute that is claimed to be suitable and satisfactory for electrical contacts consists of an alloy of 45 per cent platinum, 15 per cent gold, 25 per cent silver, and 15 per cent copper.

Much of the Cork Used Throughout the World comes from Portugal, which harvests about 50,000 tons a year.

The Flying Machine from an Engineering Standpoint—III[*]

A Review of Recent Progress

By Frederick William Lanchester, M. Inst., C.E.

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2015, Page 112, August 15, 1914

4. *Body Resistance.*—The body resistance, as already stated, varies approximately as the square of the velocity. It is therefore evident that, with a machine of given weight, since the flight resistance proper (the aerofoil resistance) is constant, the higher the flight-speed the more serious relatively does the question of body resistance become, and the design of the car and its accessories, such as alighting gear, etc., is a matter of increasing importance as the contemplated flight velocity becomes greater. The calculation of body resistance involves the computation of the resistance of each individual element, and in some cases allowances for the interference or influence of one element or portion on another. Thus in the computation of body resistance it is necessary to have at command tabulated results of the resistance of spars of various sections, wires, wheels, and the like, in addition to a sufficiency of known data as to stream-line forms of various degrees of perfection. A considerable amount of experimental data has now been collected in this direction, but a great deal yet remains to be done.[**]

The resistance of the body-shape or fuselage is a factor on which at present the information available is the least satisfactory, since it is rarely possible for the designer to adopt a close approximation to a perfect stream-line form, or a form for which the resistance coefficient has been already determined; it is usually necessary to have recourse to model experiment in each individual case. This is no more than must be expected, in view of the fact that the same applies to the design of a ship's hull when any departure is made from existing practice.

A very few years ago little or nothing was known as to the resistance of the so-called stream-line or ichthyoid body. In 1908-9 I made inquiries in the endeavor to obtain some figures on this subject. For bodies constituting a rough imitation of a good fish form, with ratio of length to diameter of about 6 to 1, the figures given in Table VIII were supplied by the different authorities named; the figures, given to me in various forms, are here reduced to represent the equivalent of normal plane in terms of the maximum cross-section.

TABLE VIII.

Authority.	Date.	——	Remarks.
Prandtl	1908	0.125	Given as approximate only.
Colliex	1908	0.100	From rough experiments at the factory of Voisin Frères.
Surcouf	1909	0.031	Given as an experimental determination by the late Colonel Renard.
British Admiralty	1909	0.032	Actual for water (ratio about 3 : 1).
		0.023	Probable for air

It would appear from more recent experiments, carried out at the Royal Aircraft Factory, and at the National Physical Laboratory, that for a well-designed stream-line form the best result so far recorded is approximately 0.07, the coefficient of fineness—length/diameter—being round about the value 4 : 1.

The plotting given in Fig. 20 is based on a series of determinations made at the Royal Aircraft Factory, with corrections (for which I take responsibility) to compensate for the difference in the coefficient of skin-friction between the velocity, 20 foot-seconds, actually employed and an assumed flight-speed of 70 miles an hour. The plotting represents the resistance coefficient for bodies of about 2 feet to 3 feet diameter.

When we turn our attention to the design of the body of machines as they exist to-day, we find that although it is becoming customary to give the fuselage a distinct fish-like outline, it is rare that any real attempt is made to adopt a definitely stream-line or true ichthyoid form, such as employed for the experimental determinations already cited, and commonly used for dirigible balloons. It is not sufficient to give a rough general outline to the body if a material reduction in the resistance is required; it is necessary to go further than this, and to avoid, as far as possible, corners and projections of every description. In many cases in the body-forms used to-day the resistance is nearly as great as that of a normal plane equal to the mid-section area, and a body with a coefficient of less than 0.5, in view of current practice, must be regarded as exceptionally good. As a consequence the resistance of the fuselage and passengers alone is often equivalent to some 3 or 4 square feet, whereas an equivalent considerably less than 1 square foot ought to suffice. It is not only necessary to avoid up-standing projections, such as wind-screens, etc., but even such things as longitudinal angles should be eliminated from the design; this latter point has been partially investigated by the National Physical Laboratory.

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[*] The James Forrest lecture delivered before the Institute of Civil Engineers on May 5th. Compare also the same author's paper on "Catastrophic Instability in Aeroplanes," SCIENTIFIC AMERICAN SUPPLEMENT, February 14th, 1914, page 100.

[**] For the resistance coefficients of spars, wires, etc., reference should be made to the various reports of the Advisory Committee for Aeronautics and the work of Mr. Eiffel and others, also section 9 following.

In the Paulhan-Tatin machine, mentioned in the researches of Mr. Eiffel, the question of body form has been studied with extreme care, the form of body employed being substantially a solid of revolution, as given in Fig. 21*a*. The only irregularity in the fuselage is in the aperture for the pilot's body, which has clearly been reduced to the minimum possible. According to the results given in Fig. 20 it would be still better, from the point of view of resistance, to design the body on the lines shown in Fig. 21*b*, making the body only of sufficient length to contain the pilot, motor, etc., and carrying the tail-organs from a tubular continuation. A model of this kind, made and tested at the National Physical Society (from designs of the Royal Aircraft Factory), gave a normal plane equivalent of about one fifth of its maximum cross-section. The form was imperfect as a stream-line body, and the small scale (1/25 full size), otherwise rendered the resistance higher than would be in actuality.—Advisory Committee, Report 74, page 177.

It is evident that with sufficient experience the body fuselage resistance of an ordinary two-seat machine should be capable of reduction to the equivalent of 1 square foot area of normal plane, since a good model of stream-line body of 5 square feet maximum section should in itself offer less than half this resistance. Added to this, we have the alighting chassis and auxiliary surfaces, the resistance of which should be capable of being designed for an equivalent of 2 square feet if the design be studied in every detail, making 3 square feet in all. On a basis of 80 miles an hour, the resistance will then amount to 60 pounds, or, say, approximately, 5 per cent. The body resistance in the machines of to-day is very much higher; it is commonly the equivalent of at least some 5 square feet of normal plane. Mr. Eiffel gives 1 square meter (10 square feet) as usual.

5. *Total Resistance.*—Fig. 22 represents graphically the position with which the designer has to cope; the horizontal line *a a* represents an aerofoil resistance coefficient of 7 per cent. The curve 2 represents (from *a a* as datum) the additional coefficient due to body resistance on the assumption that we are dealing with a machine of 1,200 pounds weight, in which the body resistance has the equivalent of 2 square feet area of normal plane curve, 3 represents similarly the added body resistance on a basis of 3 square feet; lines 4 and 5, 7 and 10, represent 4, 5, 7, and 10 square feet, respectively; curve 5 may be taken roughly to represent the best practice at the present time. It is evident that so long as flight-speeds were limited to 40 miles an hour or less, as was the case a few years ago, the body resistance remained a matter of minor importance; in fact, in the Wright machine, and in several other machines of that day, the pilot sat fully exposed, and little or no attempt was made to minimize resistance, whereas with speeds of 80 miles an hour the body resistance will, unless great care is taken in the design, considerably exceed the flight resistance proper. Fig. 22 does not represent the resistance of a given machine, flown at different speeds, but rather the resistance of a series of machines of given weight, each designed for least resistance at its own particular speed, and with body resistance equivalent to the area indicated.

Referring to Fig. 22, it will be seen that the total traction coefficient in the case of curve 5 at 80 miles an hour is, roughly, 15 per cent, the gliding angle consequently being 1 in 6.7; this is slightly better than the best figures actually obtained in the military trials of 1912. The highest speed at the military trials did not touch 70 miles an hour, so that on the basis given the gliding angle should have been better than stated; no allowance was made for the drag of the propeller, and it is possible the difference is due to this factor.

The question of body resistance has for some time been a matter of careful study by the staff of the Royal Aircraft Factory, and I understand that in some of the later models the equivalent normal plane area has been very considerably reduced. If we take an aerofoil coefficient of 7 per cent, and a curve representing 3 square feet equivalent normal plane, we find that at 80 miles an hour the gliding angle, or the resistance coefficient, should be approximately 12 per cent, or at 60 miles per hour 10 per cent. I believe this figure to be in sight, though it may not yet have been actually reached.

As illustrating the extent to which the present-day results have been anticipated by theory, in 1907, dealing with the question of the power expended in flight, I tabulated the results of calculations for gliding angles as for complete machines ranging from 12 degrees (approximately 1 in 5) to 6 degrees (approximately 1 in 10). In the military trials of 1912 the worst gliding angle recorded was 1 in 5.3, and (as pointed out in the preceding paragraph) the present-day figure is gradually approaching 1 in 10.

If we try in the light of present data to look into the future, it seems probable that the limiting gliding angle, or, rather, the minimum total coefficient of resistance may even be materially less than 1 in 10; thus, if it is found possible, in spite of structural difficulties, to obtain equal results in an actual machine to those obtained in wind-channel model tests—namely, a coefficient of resistance for the aerofoil approximately to 5 per cent—and if the body area equivalent, for a machine of, say, 1,200 pounds gross weight, can eventually be reduced to 2 square feet, a total coefficient of resistance as low as 8 per cent may prove well within reach; whether the sacrifices necessary in order to achieve such results in practice would be justified, the future alone can decide. The solution of any engineering problem is always to some degree a matter of compromise, and it would be rash to suggest that in the case of the flying machine there are not considerations of sufficient importance to render it inadvisable to run after the last 1 per cent reduction in tractive effort. A graph is given representing the coefficient of resistance on the basis of the present paragraph in Fig. 23. The aerofoil coefficient of traction is taken at 5 per cent, the weight of the machine, as before, assumed as 1,200 pounds, and the suggested total of 8 per cent corresponds to a flight speed of nearly 80 miles an hour.

Before we have finished with the question of resistance, we need to know something as to the gradient of ascent, or climbing power required. A machine that

Fig 20

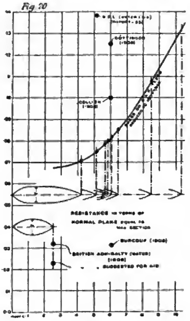


Fig. 21.

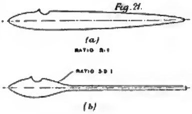


Fig. 22.

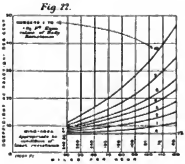
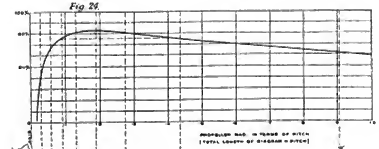
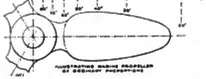


Fig 24.





ILLUSTRATING MARINE PROPELLER OF ORDINARY PROPORTIONS

Fig. 23.

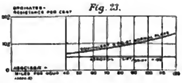
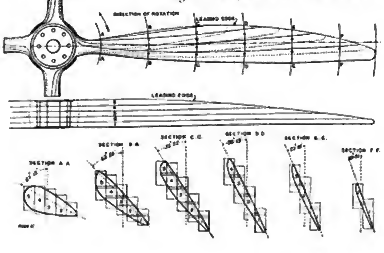


Fig. 25.



is only capable of horizontal flight is evidently quite unserviceable; it is well understood, too, that any machine with an insufficient rate of ascent is intrinsically dangerous; not only does it remain too long at low altitude, where any "fluke" in the wind is to bring about disaster, but in bad weather, when buffeted about by the wind, a pilot may find himself incapable of making altitude altogether if his initial margin of power is insufficient.

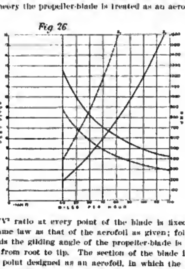
The rate of ascent for which provision has to be made depends very much upon the service for which the machine is required; for the ordinary needs of the aeronaut who wishes to make cross-country flights under fair-weather conditions, a margin of power representing an up-grade of 5 per cent or 6 per cent appears to be ample; there is probably no real advantage in any greater provision. For military or naval service, on the other hand, there are without doubt occasions when everything may depend upon the rapidity at which the machine can make altitude. I feel that I cannot do better than quote from the specifications given by the superintendent of the Royal Aircraft Factory for two types of machine, namely, "R.E. 1" reconnaissance aeroplane, and "F.E. 3" gun-carrying aeroplane.[18] For the first of these the rate of climbing demanded is 600 feet per minute, or, taking the normal flight-speed at 70 miles per hour (the specification gives maximum 78 miles per hour, and minimum 48), we have a climbing gradient of approximately 10 per cent. For the gun-carrying machine the speed is given as 75 miles per hour, and the rate of climbing 350 feet per minute, which, expressed as climbing gradient, is a trifle less than 5½ per cent. Manifestly a machine carrying a gun of some kind (presumably a machine-gun), and we may assume an adequate supply of ammunition, and perhaps a few square feet of bullet-proof armor plate, needs to sacrifice something in the matter of climbing power.

There is good reason to suppose that if a demand for higher speeds than those at present attained is in the future to be satisfied, success will depend to some extent upon our ability to build larger and heavier machines. By reference to Figs. 22 and 23 it will be seen how soon with increased flight-speeds the question of body resistance becomes a disproportionate factor; it is manifestly impossible in a machine of given size to reduce the equivalent normal plane area beyond a certain point, but it is evident that by increasing the weight and power of the machine the effect of such body resistances may be rendered less important, since an increase in weight and power does not require a proportionately serious increase in the size of the members to which the body resistance is due. Also since the square of the product of *l* and *V* varies directly as the weight (where *l* represents the linear size of the aerofoil) the value of ξ is also a function of the weight, and diminishes slightly as the weight is increased.[19]

6. *Propulsion.*—We are now in a position to consider the question of propulsion. Whether we appeal to experience or theory it would appear that there is only one method of propulsion available, namely, the screw-propeller.[20] The problem of propulsion, whether aeronautical or submarine, is essentially the same; the laws of dynamic similarity, with certain reservations, are strictly applicable. Roughly speaking, the conditions of usage of propellers in water and air may be compared by merely taking cognizance of the relative densities of the two media—approximately 800 to 1. The laws of dynamic similarity indicate that this relation is not exact, but any refinement of theory on this score is of academic rather than of practical importance. Apart from fine points of this kind, there is a limitation that renders the air propeller and the marine propeller not strictly comparable; this limitation is due to the appearance of the phenomenon known to the naval engineer as cavitation. The law of the relation of pressure to velocity for least resistance applies to the blade of the screw-propeller precisely as it does to the aerofoil itself, so that if a propeller is being designed for least resistance the pressure per square foot at any point of the blade must bear its constant relation to the square of the velocity of the blade through the fluid at that point. In the case of the marine propeller this results in a speed being reached (at about 20 or 25 knots speed of vessel) at which the velocity of the blade-tips is such that the negative pressure (on the back of the blade), based on the law of least resistance, is greater than the hydrostatic (absolute) pressure. Under these conditions a vacuum is formed in the vicinity of the blade extremity, and the system of flow is impaired; this is the condition of incipient cavitation, and as the speed is progressively increased the vacuum invades more and more of the blade area, until the greater part of the propeller becomes ineffective. From the critical speed upward the design of the marine propeller becomes a compromise. The extremity of the blade is first designed broader to avoid developing pressures sufficient to initiate cavitation, and then, owing to the additional skin friction thereby involved, it is found desirable to adopt higher pitch/diameter ratio to prevent the extremities cutting the water with excessive velocity. Eventually the propeller for high-speed craft becomes one of extremely coarse pitch, with blades of short or saucer-like form. No such thing as cavitation is experienced in the aeronautical propeller; if we should require to deal with propeller-blade speeds approaching the velocity of sound, we might find something analogous, due to the high rarefaction of air, but at present the aeronautical designer can afford to ignore all question of cavitation.

It is frequently stated that the theory of the screw-propeller is entirely empirical and quite unsatisfactory; this is not my opinion. The theory of the screw-propeller, based on the theory of the aerofoil as laid down in my "Aerodynamics,"[21] appears fully to meet the requirements of the aeronautical designer. According to this theory the propeller-blade is treated as an aerofoil, its P/V^2 ratio at every point of the blade is fixed by the same law as that of the aerofoil as given; following this the gliding angle of the propeller-blade is constant from root to tip. The section of the blade is at every point designed as an aerofoil, in which the true helical surface corresponds to the horizontal plane in flight.[22] Under these circumstances it is shown in my work that each point of the propeller-blade has efficiency proper to itself, and is represented by a curve as plotted in Fig. 24, which corresponds to a gliding angle of 6 degrees, or, approximately, 10 per cent. Under these conditions it will be seen that the region of maximum efficiency is just over 81 per cent. Unfortunately, we cannot use only the region of maximum efficiency; we have to employ the blade of considerable length, and consequently parts of the blade have an efficiency below the maximum. If we take a propeller of the usual proportions, in which the pitch is about 1¼ times the diameter, that is, such a blade as is represented in Fig. 24, we see that the marine engineer declines to employ any portion of the blade with an efficiency of less than about 92 per cent of the maximum—that is to say, the efficiency of different points of the blade varies from 77.5 to 81 per cent, or, theoretically, the limit of efficiency of such a propeller should be round about 77 per cent. Unfortunately, a propeller "in being" cannot consist of blades alone, it requires a boss and a connection between the boss and the blades, and in driving these functionally useless parts through the water a considerable farther loss is inevitable. Probably it is for this reason that the actual efficiency of a marine propeller rarely exceeds 70 per cent. In my work, a design is given of an aerial propeller based on theory alone, in which a very conservative estimate is taken of the gliding angle. If, in the light of present knowledge, we assume the propeller-blades being of the aspect-ratio corresponding to that of my 1894 gliding model, the gliding angle or resistance coefficient will be about 5 or 6 per cent, and we might anticipate a theoretical limit to the propeller efficiency of 88 or 90 per cent. We have here, as in the marine propeller, to provide a boss and arms, and we require to take into account the fact that it never pays in practice to take the full diameter of the propeller that theory would indicate (it is better to sacrifice a few per cent efficiency to save weight and clearance diameter). Everything considered, I am disposed to put a limit of efficiency of an aeronautical propeller at about 85 per cent: this is higher than has been found possible in marine engineering.[23]

Fig 26



My method of propeller design has been adopted and employed for some years by the superintendent and staff of the Royal Aircraft Factory with very satisfactory results; at present there is but little available information on the question of efficiency owing to the fact that the arrangements at the disposal of the Royal Aircraft Factory do not permit of the testing of full-sized propellers.

Working drawings of a propeller, designed at the Royal Aircraft Factory by this method, are given in Figs. 25 and 26. For the full exposition of the system of "lay out," reference should be made to the work already referred to.

As an alternative and purely empirical basis of treatment, we may fall back on our experience in marine propulsion. There is a practical rule which appears to be commonly adhered to in the design of successful marine propeller for moderate speed sea-going craft. The area of the propeller disk is approximately 1 per cent of the total wetted surface. This rule has been found by me to represent a rough average of the practice in various cases,[24] but whether it is an accepted rule or not I do not know. Let us take the case of a flying machine involving, say, a thrust of 200 pounds at 80 feet per second; at this speed the frictional air resistance will be approximately 0.035 pound per square foot of surface (0.07 pound per square foot of lamina—i. e., double surface); thus the resistance of the machine is approximately represented by 6,000 square feet "wetted" surface, and, following the rule given in the case of water, the propeller-disk should be 60 square feet; this corresponds to a propeller diameter of about 9 feet. In an actual machine of about this size the propeller is commonly of about 7 feet to 8 feet diameter, which, taking everything into account, is in substantial agreement. The propeller employed in flight is of necessity (from consideration of the engine revolution speed) of finer pitch than that of best efficiency. Under these conditions theory shows that the correct diameter is less than that of the propeller of best diameter pitch ratio, such as employed by the naval architect.

There are (in the present state of the art) two prominent reasons for the adoption of a propeller for aeronautical machines of finer pitch than that of greatest efficiency; first there is the question of suiting the pitch of the propeller to the running speed of the engine. For the power necessary in a modern aeroplane (from 50 to 100 horse-power) a stroke of about 5 inches is found to design well in proportioning the engine; now it is uneconomical both from the point of view of weight-saving and of gasoline consumption to employ too low a piston speed; in fact, for any given dimensions of cylinder the power developed is within limits roughly proportional to the piston speed. Taking a piston speed of 1,000 feet per minute and 5-inch stroke, we require 1,200 revolutions per minute = 20 revolutions per second. Assuming a velocity of flight of about 80 feet per second, the effective pitch of the screw requires to be 4 feet, or approximately equal to half the diameter of the screw, instead of at least equal to the diameter, as in a good marine propeller.

It is, of course, not difficult to gear down from the engine to the propeller, in fact, this has been frequently done, but, since gearing involves a tax of approximately 5 per cent of the horse-power, it is evidently better to drive direct and sacrifice something in the efficiency of the propeller, more especially as this course involves a far lower torque on the propeller-shaft, and consequently a lower recoil torque on the framework of the machine.

(*To be continued.*)

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[18] Advisory Committee for Aeronautics, Report 1912–1913, page 267.

[19] Compare Appendix I.

[20] Nature's method of propulsion—wing-flapping—besides being very objectionable from a mechanical point of view, shows certainly no higher degree of mechanical efficiency than the screw-propeller.

[21] "Aerial Flight," vol. I., ch. ix.

[22] There is one factor which affects the analogy between the aerofoil and the propeller-blade; the latter is not able to the same extent, to hold or accumulate a dead-water wake; the propeller-blade sheds its dead water continuously by centrifugal force. The extent to which this affects the problem has yet to be determined.

[23] There should be nothing to prevent the marine propeller (at speeds below the cavitation point) giving as high an efficiency as the aeronautical propeller, were it not for the limit imposed by the strength of materials. To obtain the highest efficiency even in an air-propeller it may be found necessary to abandon the wooden blade and substitute a solid nickel-steel blade of somewhat the sectional form given in Fig. 16 ante; this, in the case of an 8-foot propeller, would mean a blade 4 feet long, the outer 3 feet of which would be the effective blade, the maximum width in the widest part being no more than 3 inches or 4 inches. If any attempt were made to design such a propeller for marine work, there is no material known at the present time that would stand the stress involved, the pressure-reaction, speed for speed, would be about 800 times greater in water than air, and the aspect ratio of the blade that can be utilized for marine work is strictly limited by this fact; even the softest of timber is relatively far stronger as a medium for the construction of an aeronautical propeller than any known material, even tempered tool steel, would be for marine work. In the design of an aeronautical propeller, advantage may be taken of the fact that a very slight forward slope of the blades relieves the blades of all bending stresses, the resultant of the centrifugal force and pressure reaction is in the line of the blade, and the latter is consequently stressed in pure tension.

[24] The average of a number of war vessels, capable of about 18 to 20 knots speed, gave the figure 1.3 per cent. Two typical low-speed merchantmen (from particulars supplied by the builder) gave exactly 1 per cent.

NEW BOOKS, ETC.

FILTERS AND FILTER PRESSES FOR THE SEPARATION OF LIQUIDS AND SOLIDS. From the German of F. A. Bühler. London: Norman Rodger, 1914. 8vo.; 184 pp. Price, $4.80.

The subject of filters is a most important one in chemical technology, for the separation of solids from liquids is a frequent and regularly recurring problem in chemical factory practice. To describe and represent pictorially those forms of apparatus that up to the present have proved themselves the most useful is the object of this treatise. The improvements in filter presses are many and it is wise for chemical engineers to keep pace with the times. All the standard and many of the unusual filters and filter presses are described. The book is illustrated by 427 engravings, and there is an appendix dealing with the patents granted in the United Kingdom for filters, filter presses, etc.

ENGINEERING GEOLOGY. By Heinrich Ries and Thomas L. Watson. New York: John Wiley & Sons, Inc., 1914. 8vo.; 672 pp. Price, $4.

For some years the authors of this book have been giving to students of civil engineering in their respective universities a special course in geology as applied to engineering. The method followed by them has met with much success, and since the plan adopted has generally been put into operation in other universities, it has encouraged them to believe that it might be of service to others to prepare the present work. There are probably but few people of observation and practical experience who doubt the value of proper geological training for the engineer, since he must be prepared to meet and even to solve many problems which involve geological principles. For such knowledge it is necessary that the engineer should have adequate training in at least those fundamental principles of geology which relate to engineering problems. The authors have attempted to emphasize throughout the book the practical application of the topics treated to engineering work, because hitherto in many engineering courses of study the subject of geology has not been given the attention which they think it should receive from both professors and students. Although this book is intended primarily for civil engineers, it is hoped that it may be of use to others interested in applied geology. The book is excellently illustrated.

THE CHEMISTRY OF RUBBER. By B. D. Porritt. New York: D. Van Nostrand Company, 1913. 16mo.; 93 pp. Price, 75 cents.

The monograph is intended for those interested in rubber from a chemical point of view, and the description of technical practice has therefore been limited to the details which are necessary for a clear insight into the chemical questions involved. The literature of rubber is not as extensive as might be thought, and the present work fills a niche of its own.

X-RAYS. An Introduction to the Study of Röntgen Rays. By G. W. C. Kaye, B.A., D.Sc. New York: Longmans, Green & Co., 1914. 8vo.; 252 pp. Price, $1.25.

The present volume aims merely at giving an account of such of the present-day methods and apparatus as appear valuable or novel, and which in many cases can only be found scattered throughout many journals. It treats critically, and here and there more comprehensively, some of the features which have laid claim to the interests of the writer from time to time. It is concerned to some extent with the developments of theory as well as of experiment, and it attempts to convey a notion, however disconnected and ill-proportioned, of the historical trend of events from Prof. Röntgen's world-famous discovery in the year 1895 down to the end of the year 1913. The book is well illustrated by clear diagrams.

AT HOME IN THE WATER. Swimming, Diving, Life-saving, Water Sports, Natatoriums. By George H. Corsan. New York: International Committee of Young Men's Christian Associations, 1914. 16mo.; 197 pp. Price, $1.

The subject of swimming is constantly gaining in importance, and it is safe to say that at no time have there been as many competent swimmers as at the present. The volume before us is exceedingly valuable, dealing with swimming in all its phases, diving, life-saving and water sports. There is also a short chapter on the construction of swimming pools. In 1913, over 7,000 persons lost their lives through accidental drowning. It is a strange thing that many who are daily exposed to dangers from drowning do not know how to swim. This is true of lumbermen, of men in the navy, and of many who are members of crews on ships. Everyone should know how to swim for at least three reasons. First, it is a splendid form of exercise; second, it imparts self-reliance and courage; third, it might prove a means of saving lives. The Young Men's Christian Association has taken up this question in a very large way, their slogan being "Every Man and Boy in America a Swimmer." The author has introduced two new features in teaching swimming. In the first place, he heats the water in the pool to 80 degrees, so that the pupils will not suffer from cold. He also uses cotton water wings, which are used under the hips, so that the pupil can give all his attention to the arm movements. The volume will prove very valuable in public schools and summer camps and watering places. It will be found greatly helpful to individuals as a first effort in learning to swim.

PRATIQUE DE LA CONSTRUCTION. BETON ET MORTIER DE CIMENT. Armés ou non Armés. Avec Etablissement Rationnel des prix de Revient. By Frederick W. Taylor, M.E., Sc.D., and Sanford E. Thomson, S.B. Translated and adapted by M. Danne. Paris: H. Dunod et E. Pinat, 1914. 720 pp. Price, $5.50.

This is a translation of a work by two members of the American Society of Civil Engineers and goes into the whole subject in the greatest possible detail. It is filled with valuable tables and illustrations. The American practice has been very successful where concrete is concerned, and we are not surprised that French engineers have recognized its superiority.

AIDE-MEMOIRE DE L'INGENIEUR-CONSTRUCTEUR DE BETON ARMÉ. By Jean Bruive. Paris: H. Dunod et E. Pinat, 1914. 387 pp. Price, $3.

This volume will prove of particular value in connection with the preceding work. It is accompanied by a large number of illustrations of executed work, diagrams, sections, plans, etc. It is also accompanied by an excellent glossary in five languages.

LA VIE DES VÉRITÉS. Par Dr. Gustave Le Bon. Paris: Ernest Flammarion, Editeur, 1914.

Admirers of Dr. Le Bon's works will be pleased to note the appearance of his latest volume, which, like the former ones of the series, is of a philosophical nature, but is written in a clear and easily-read style. The present volume is devoted to the subject of the various "truths," real or supposed, which prevailed during the course of ages, commencing with religious and moral ideas and philosophies, and coming down to the times of modern science. The latter portion of the work treats of the relation of science to other branches of knowledge, and the advantage which it possesses of being able to formulate laws which have a universal bearing. Owing to the wide scope of the work, we will not attempt to review all the subjects of which it treats, but its study will be of value to all who are interested in such questions. The author shows the results which are to be expected of science in the explanation of the universe, and also its limits and the "truths" which are still inaccessible to us, the work taking in all the recent ideas in this field. On the whole, the book claims the same interest as its predecessors.

SCIENCE ET RELIGION. Par Emile Boutroux. Paris: Ernest Flammarion, Editeur, 1913.

The time-honored conflict between science and religion is here presented in a new light by M. Boutroux, taking into account all the recent scientific theories such as prevail at the present time. He considers that religion and science each has its legitimate field which is distinct and separate, and that they do not deal with the same order of ideas, the conclusion being that in spite of their relations which can be said to exist in a certain degree, these two branches remain distinct, and even though there should be a conflict between them the result will only have the effect of strengthening each, seeing that both are endowed with a high degree of vitality. The book is ably written, and is a valuable contribution to this subject.

MODERN METHODS OF WATERPROOFING, Concrete and Other Structures. By Myron H. Lewis, C.E. New York: The Norman W. Henley Publishing Company, 1914. Price, 50 cents.

This reprint forms Chapter XXX of the author's new book, entitled, "Popular Handbook for Cement and Concrete Users." It is a condensed statement of the principles, rules and precautions to be observed in waterproofing and damp-proofing structures and structural materials.

CONQUEST OF THE TROPICS. By Frederick Upham Adams. Garden City, N. Y.: Doubleday, Page & Co., 1914. 12mo.; 368 pp. Price, $2 net.

The present handsome volume is the story of the creative enterprise conducted by the United Fruit Company, which has been so potent in the universal distribution of the banana and other tropical fruits. This book is the first in a series planned to describe certain big businesses, whose history and operation concern and should interest the public. The book is handsomely gotten up and reflects great credit on the author and publishers as well.

THE AMERICAN FERTILIZER HAND BOOK. Philadelphia: Ware Brothers Company, 1914. Quarto. Price, $1.

This is a standard reference book and directory of the commercial fertilizer industry and allied trades. It is in truth the buyers' guide of the trade, stating where to obtain plant-equipment, raw materials and the expert service required in the fertilizer industry. It contains special articles and statistics of interest to the fertilizer trade. It also contains a directory of the fertilizer manufacturers of the United States, together with a classified directory of the allied fertilizer trades, a directory of the cottonseed oil mills and a directory of packers and renderers. It is arranged in a very common sense manner, and the information given in each instance is very specific.

GUNSHOT INJURIES. How They Are Inflicted. Their Complication and Treatment. By Colonel Louis A. Lagarde, United States Army Medical Corps (Retired). New York: William Wood & Co., 1914. 8vo.; 368 pp. Price, $4 net.

The necessity for a book on gunshot injuries for use of the military service and the American surgical profession, was not apparent until very recently. The older volumes, such as those of Otis, supplied all the wants of the profession in this particular branch of surgery. But now the subject of gunshot injuries as a whole has been so modified by radical changes in the armament of the nations, and the results in wounds by firearms have been so modified by modern methods of treatment, that the works of Otis and his contemporaries have been entirely superseded as far as practical surgery is concerned. The demand of the military and civil surgeon now requires a presentation of the important subject of gunshot injuries as inflicted by a new armament and treated after the methods of modern surgical practice. The wounds produced by the firearms fifty years ago and the results of the treatment then in vogue form no guide for the study of the subject to-day. The author calls attention to the fact that there is very little difference between gunshot injuries in war and the gunshot wounds the civil practitioner is called upon to treat in civil practice. The subject is a peculiarly interesting one to all physicians and surgeons, and this book, which is a thorough scientific treatise, is worthy of every attention.

THE BACTERIOLOGICAL EXAMINATION OF FOOD AND WATER. By William G. Savage, B.Sc., M.D. (Lond.), D.P.H. Cambridge, England: University Press, 1914. 8vo.; 173 pp. Price, $2.

In view of the increasing importance of the study of public hygiene and the recognition by doctors, teachers, administrators and members of public health and hygiene committees, it is interesting to know that the Syndics of the Cambridge University Press have decided to publish a series of volumes dealing with the various subjects connected with public health. When it is considered that the regular text-books and manuals upon bacteriology are, for the most part, written by bacteriologists whose investigations and routine work are in the field of pathological bacteriology, it will be seen that there is a field for a work of another type. In marked contrast is the inadequate treatment given to the bacteriological examination of water, air, foods and the like. This branch of bacteriology is of immense practical importance, and justifies a more extended treatment. The aim of this volume is to remedy this defect and to make available a practical manual dealing not only with the examination of these substances, but also with the deductions to be drawn from the bacteriological data obtained from their examination. Much of the available information is only at present to be found in original papers not always readily accessible.

THE MENTAL HEALTH OF THE SCHOOL CHILD. The Psycho-Educational Clinic in Relation to Child Welfare. Contributions to a New Science of Orthophrenics and Orthosomatics. By J. E. Wallace Wallin, Ph.D. New Haven: Yale University Press, 1914. 12mo.; 463 pp. Price, $2.

Physical defects in children are not restricted to any clime, race, environment, or social condition. The children in sunny Southern California, no less than the children of the cold or humid North, East or West, the children of the country, no less than the children of the city; the children of the rich, no less than the children of the poor—labor under various forms of physical handicaps which are usually subject to amelioration or cure. Dr. Wallin has made a careful and prolonged investigation of the child mind. His conclusions are based on the statistical study. Realizing such facts as the above, he has set about to define the most effective means of correcting such deficiencies. The book contains tables which will be of the greatest service to all interested in the improvement of the conditions of children.

OUR MANY-SIDED NAVY. By R. W. Neeser. New Haven: Yale University Press. London: Humphrey Milford, Oxford University Press. 8vo.; 220 pp. 41 halftone engravings. Price, $2.50.

The United States Navy needs only to be known to be appreciated, and the only way to obtain a thorough knowledge of the navy is to go to sea in one of its ships, mingle with its officers and men, watch its maneuvers, target practice, boat drills, etc., and thus get into intimate touch with its daily life and service. This the author of the present volume has done, and probably there is no layman who has a more thorough knowledge of the navy, as to its organization, efficiency and daily life, than he. The handsome volume before us includes descriptions in the several chapters of "The Fleet at Sea," "The Naval Station at Guantanamo Bay," "The Organization of the Ship," "The Blue-Jacket's Daily Life," "The Battleship as an Educational Institution," "The Engineering Competition," "Athletes in the Navy," "The Sailor as a Soldier," "The Work of the Torpedo Flotilla" and "Target Practice." There are four appendices in which are described "The Navy's Services in Time of Peace," "Organization and Distribution," "The Organization of the Ship," and "The Weekly Routine on Shipboard." To a faculty of critical observation Mr. Neeser adds an attractive literary style, and the book teems with the atmosphere of the sea. Every chapter is thoroughly readable.

PHOTOGRAPHY IN COLORS. A Text Book for Amateurs and Students of Physics. By George Lindsay Johnson. New York: E. P. Dutton & Co. 16mo.; 243 pp. Price, $1.25 net.

This is the second edition of a valuable work on photography in colors and contains a chapter on kinematography in the colors of nature. The work has been so completely revised that it may be considered as a new book. The original sections have been recast and considerably amplified, while additional chapters on auto-color printing and on the nature of light, color and shadows, still further bring the book up to date. It is illustrated with thirteen full-page plates (five of which are in color), and numerous illustrations in the text.

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Investigations at the Cryogenic Laboratory at Leyden*

By C. A. Crommelin,
Conservator of the Physical Laboratory of the University of Leyden.

THOSE who have read items concerning the question of low temperatures know that Prof. Kammerlingh Onnes has built up at Leyden an institution unique in the world, the Cryogenic Laboratory (*Κρύος*, cold), where not only are obtained the very lowest temperatures, but where it is possible to study the properties of bodies at such temperatures.

To do this, it is necessary to understand the liquefaction of gas, and to realise that this liquefaction is only a means to an end. It does not suffice to produce a few drops, more or less fugitive, of a gas, said to be permanent, and to prove thereby that it can be made liquid, but rather to obtain it in great liquid masses in static conditions and to manipulate it conveniently in such fashion as to determine the constants of temperature of spaces relatively large, and to do all this at temperatures increasingly low. Such results can be obtained only by the rigorous application of a uniform method which is applicable to the working of powerful and complicated machines and apparatus, but which, also, must be capable of furnishing results of great precision. Thus the unique laboratory of Leyden gives to the uninformed visitor the appearance of a manufactory.

It is indeed a factory which it is necessary to operate with a corps of scientists, preparers, and skilled mechanicians, working together throughout a dozen consecutive hours if one would make a series of researches at the very low temperatures which the liquefaction of hydrogen and of helium demand.

Without doubt it is on account of the necessary slowness of procedure that Prof. Onnes was not the first to liquefy hydrogen, but he has surely contributed to that success with helium, the most difficult of all the gases to liquefy, and the laboratory at Leyden is to-day the only one in the world where such results have been obtained. It is also the only one to which the scientists of the entire world can come to study the questions which interest them concerning low temperatures. In this respect it offers the greatest hospitality and the most splendid facilities. A programme is established in consultation with Prof. Onnes, who, aided by his regular fellow workers, outlines the task; the apparatus necessary for the experiment is prepared, and then in collaboration with the visiting scientist the experiment is carried to its finish.

In what is to follow nothing will be said concerning the mere liquefaction of gas nor of the personal work of Prof. Onnes, who succeeded in liquefying helium in 1908, nor of the technical outfit of the Leyden laboratory. Nor is anything said about the cryostats for liquid helium, which through their excellent planning and construction have made the measures of this gas possible. Instead this article will sketch the principal experiments and researches which have been conducted with low temperatures these past few years. As may be seen, these researches constitute one of the most interesting chapters in the history of science, for they all treat of the constitution of matter, a question that at this moment is in the minds of all the scientists.

Why are these investigations of low temperatures so interesting? The reply to this question is not to be given in a single word. Different researches have often a character of their own. The desire to study the conditions of various substances under temperatures as far apart as possible, and to support the hypothesis of van der Waals by experimental results, was without doubt one of the principal motives of Prof. Onnes in establishing his own special laboratory. The matter can be considered in a more general way, however. Most of the properties of bodies depend more or less on molecular activity induced by thermal conditions. But this activity often has the effect of obscuring the phenomena. One may expect that as the temperatures become lower and lower, and the activity weaker and weaker, the phenomena will present themselves more clearly and well defined. It is this general consideration that is the foundation for the hope that the investigations of Prof. Onnes will add much to our knowledge of molecules and atoms, and this, at a time when but few even among the scientific men fully realize the importance of measures at low temperatures. One cannot help, therefore, admiring the far-sightedness of this observer when it is evident that an entire section of modern physics depends on the very low temperatures that he is studying.

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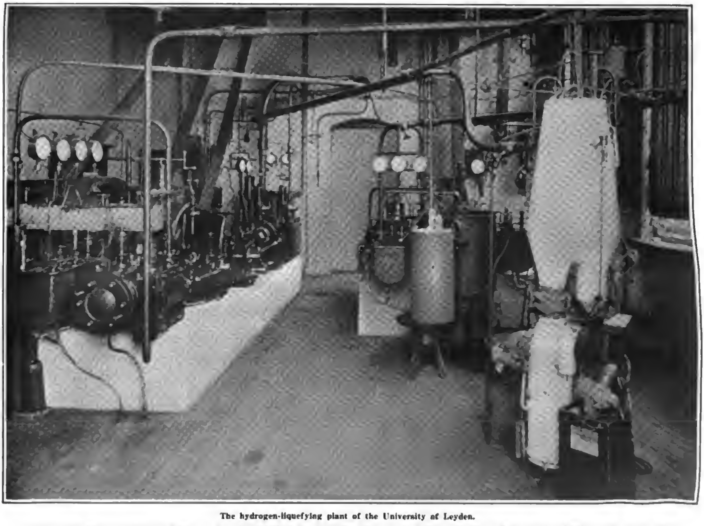
* Translated from a paper in *Le Génie Civil.*



The hydrogen-liquefying plant of the University of Leyden.

In the left foreground is the hydrogen compressor; in the middle ground, air pump for boiling liquid air (preliminary hydrogen refrigerant) under reduced pressure; in the center, two hydrogen compressors; at the right, liquefier yielding 10 to 12 liters per hour.

A. THERMODYNAMIC RESEARCHES.

The researches in thermodynamics, which for a long time constituted the entire work accomplished at the Leyden laboratory, remain to-day an important part of its duties. In the studies of gas, it is above all the monatomic gases that have especial interest on account of the simplicity of their structure. Among them helium occupies the first place. The determination of certain isotherms, notably to the temperatures of liquid hydrogen, make it possible to estimate the constant, a, of van der Waals and critical data; estimates which together with the law of corresponding states guided Onnes in the construction of his apparatus for liquefying helium. A short time after its liquefaction (July 10th, 1908), Prof. Onnes tried to obtain solid helium, but without success. Even under a pressure of 0.2 millimeter of mercury, the temperature being lowered to 1.15 deg. Kelvin (the lowest ever yet obtained), helium remained liquid without even showing a trace of viscosity.

Researches in this direction have not been carried further, for there were more important things to do. Prof. Onnes next determined the vapor tensions, critical data (5.25 deg. Kelvin and 2.75 atmospheres) of helium, and the density of its liquid, and of the saturated vapor at different temperatures. He observed a curious anomaly: the density of the liquid is at its maximum in the neighborhood of 2.2 deg. Kelvin. On this point Prof. Onnes has made theoretical deductions that are very interesting.

With reference to argon, he has determined an extended range of isotherms, its critical data (−122.44 deg. Cent. and 48 atmospheres), the triple point (−189.30 deg. Cent. and 51.57 centimeters of mercury), the normal boiling point (−185.84 deg. Cent.), the tensions of solid, liquid, and vapor to −210 deg. Cent. and the densities of the liquid and saturated vapor. These are his latest determinations, items very important for the industry of the distillation of liquid air, and which shows that argon obeys the law of rectilinear diameters of Cailletet and Mathias. Further, it is of interest to know that argon is thus far the only substance with low critical temperature for which the different thermodynamic data are known through a region of temperatures quite extended. Among these the isotherms in the neighborhood of the critical point are of first consequence. By means of these researches it has been possible to compute a number of important constants for argon, for example, the heat of its vaporization, the values of $\left(\frac{dp}{dT}\right)_v$, from which one may estimate the very slight variation in function of the temperature of the "internal pressure" of Amagat, that is to say, $\left[T\left(\frac{dp}{dT}\right)_v - p\right]v^2$, etc.

The researches on neon, due to Georges Claude, offer considerable difficulty from the experimental point of view, because the critical temperature of this substance lies in a region so hard to reach between −217 deg. Cent. (liquid oxygen under a pressure of 2 millimeters of mercury) and −253 deg. Cent. (liquid hydrogen under atmospheric pressure). A provisional determination of the critical pressure (30 atmospheres) has been made, and apparatus for the experiments is under construction, so that results may presently be expected in the matter.

In the work with diatomic gases there should be mentioned the establishment of a series of isotherms for hydrogen above the critical point (from +100 deg. Cent. to −217 deg. Cent.) at pressures relatively high, and below this point (at temperatures of liquid hydrogen) at low pressures. By means of this group of isotherms there has been calculated with reasonable precision the corrections for an international hydrogen thermometer (of constant volume at 1,000 millimeters pressure at 0 deg. Cent.) to make it accord with the absolute thermodynamic scale of Kelvin. These determinations are of extreme consequence in the thermometry of precision at low temperatures. The same computations have already been made for a helium thermometer, and a direct comparison of the two thermometers, recently accomplished, confirms the results obtained to within 0.02 degree.

The densities of hydrogen, liquid and solid, and at different temperatures, have already been determined, as well as the measurements of contraction which ensues on solidification; also the vapor tension at atmospheric pressure and below it (normal boiling point −252.76 deg. Cent.; triple point, −259.14 deg. Cent. at 5.07 centimeters of mercury), facts which are very important for thermometry, since in measuring vapor tension with a precision now easy to secure one passes the bath constant (0.01 degree), so that an apparatus to determine the vapor tensions of hydrogen appears to be the most convenient thermometer for the temperatures of liquid hydrogen.

For oxygen, as for argon, the curves have been determined for the densities of the liquid and the saturated vapor. Here it is found that the substance follows the law of mean densities and the triple point is determined (−218.4 deg. Cent. and 1.5 millimeters of mercury). For nitrogen and oxygen, measures have been made of the critical data as well as a number of vapor tensions. Researches on the "diameter" of nitrogen are actually in course of preparation.

Work has also been done on the easily liquefiable gases. At several places, and especially at the International Congress of Refrigeration, at Paris in 1908 and Vienna in 1911, the representatives of the industries of cold drew attention to the advantages there would be in new and better determinations of certain thermodynamic constants of the gases employed in refrigerating machines, particularly those of ammonia and methylchloride. Since such researches seemed likely to lead to important increases in scientific knowledge, Prof. Onnes decided to make the needed determinations in the laboratory at Leyden. He began by the deep discussion of the constants already set forth by other investigators, and also made plans to determine between such results when they were not in accord, and finally to fill the considerable gaps which existed in the series.

He found that it was necessary:

1. For ammonia, to determine the isotherms between +20 deg. Cent. and +100 deg. Cent. and between 1 and 16 atmospheres; the isotherms of the vapor at 0 deg. Cent. at low pressures; and the vapor tensions at high pressures (up to 16 atmospheres) in order to choose between the two non-concordant series of Regnault; and at low pressures (1 atmosphere) to decide between disagreeing series of Brill and Davies. The knowledge of the isotherms combined with that of the vapor tensions served for the computation of the densities of the saturated vapor, the more valuable since direct determinations in the apparatus that have served for argon and oxygen offered experimental difficulties.

2. For methylchloride it was essential to determine an isotherm at +20 deg. Cent., to choose between the series of Kuenen and Leduc on the one hand and those of Brinckmann and Baumé on the other, and to secure a group of isotherms at low temperatures and pressures. Then it was necessary to determine a certain number of vapor tensions to check the values of Regnault. By combining these new results with those already at hand it became possible to calculate the densities of the saturated vapor as well as the heat of vaporization at different temperatures. In this way it became possible to determine for the two liquids the specific heats for liquid and vapor and thereby to construct the entropy diagrams of Mollier.

At the present writing all the measurements here spoken of, excepting the calorimetric ones, have been determined with the greatest of care, and a portion of the results, the plan of investigation and the discussion of previous measures, have already been published in a report presented to the Third International Congress of Refrigeration at Chicago, September, 1913. The other reports will appear very soon. It is but fair to predict that these results will be of fundamental importance to science and to the industries engaged in the production and use of cold.

Especial interest attaches to the measurements of the vapor tensions of carbonic acid at low temperatures (from −135 deg. Cent. to −183 deg. Cent.) where the pressure is so weak that the manometer is necessary to measure them, or even the Knudsen manometer, and expression is in baries (1 barie = 0.000,740,586 millimeter of mercury). Determinations of this character have especial importance, for they connect themselves with Nernst's hypothesis of heat, whereby this scientist has deduced the formulas of vapor tensions.

In regard to gases easily liquefiable one cannot omit the researches relative to butane, which has recently been investigated in various ways, and for which, among other things, there have been determined the vapor tensions, the densities of the liquid, and the vapor saturation at different temperatures.

B. ELECTRICAL RESEARCHES.

The researches relative to electricity also form a chapter of fundamental importance among the many works at Leyden. In the course of the researches the study of resistances of metals at low temperatures has led Prof. Onnes to a very interesting discovery. The general study of resistances of metals has been already the subject of numberless investigations. Basing his conclusions on the results obtained by himself and those of Dewar, and giving attention to the theory of electrons in metals, Prof. Onnes believes that resistance reaches a minimum at a very low temperature, to increase very rapidly below this degree and become infinitely great when absolute zero is touched. This conception is reached through considering electrons as having motion between the molecules of a metal as an "electronic vapor" which, at extreme temperature, condenses in a solid state on the molecules. The carriers of electricity being reduced to immobility, the passage of electricity becomes impossible. If, on the contrary, the electrons are considered as "electronic gas," the conclusion must be that in reducing the temperature the resistance must be lowered also. Of the two conceptions, the first would seem to be the more plausible.

In beginning his measurements of liquid helium, Prof. Onnes tried to find in this region of low temperatures that of the lowest resistance. But he observed a curious phenomenon; the resistance of gold and platinum became constant in the whole region of liquid helium. He thought that perhaps metallic impurities might be the cause of this residual resistance and that it ought to disappear at absolute zero. He hastened, as well as one can hasten in such delicate and difficult work, to repeat the experiment with mercury, a metal that can be obtained in almost absolute purity. The results were altogether unexpected; for the resistance decreased regularly till in the vicinity of 4.21 deg. Kelvin, that is to say, a little above the boiling point of helium, then fell suddenly to a value less than one millionth of that at the point of congelation, and fell immediately afterward to a billionth of that value when the lowest temperature obtainable was reached.

Tin and lead present the same phenomena, the former maintaining its regular fall to 3.8 deg. Kelvin, and lead to about 6 deg. Kelvin. The resistances of the three metals become in their new state what Prof. Onnes has been pleased to term "superconductive," so small that it has not been possible to measure with precision. But one can gain a notion of the minuteness from the fact that the Leyden scientist has been able to pass through the mercury, electricity, with a current-density of 12 amperes to the square millimeter without measurable manifestation of heat.[1]

Now what does this consideration of these strange phenomena teach us? It appears at the outset that the hypothesis of "electronic vapor" must be abandoned. Prof. Onnes had then the idea of applying Planck's hypothesis of oscillators to the electronic hypothesis of metals. In his quanta hypothesis Planck has introduced oscillators of which the mean energy disappears at a temperature clearly below absolute zero. If we now consider the oscillators as obstacles to the movements of electrons, we can understand that somewhat below absolute zero, the oscillators being in repose, and the electrons having now no opposition, the passage of electricity is practically free. When one computes the mean free path of the electrons at this temperature the result is in values of the order of a meter.

Space will not permit of the notice of very interesting applications that befall superconductive metals in intense magnetic fields, nor the considerations of Prof. Onnes on various other theoretical questions related to superconductivity. But something must be said of researches relative to the Hall phenomenon (when a magnet acts on a conductor it affects also the current flowing through this conductor), and the change of resistance in the magnetic field, which investigations are the subjects of a number of memoirs emphasizing the theoretical side of the researches. The two phenomena have been measured from ordinary temperatures to those of the liquefying of hydrogen for bismuth, gold, silver, copper, palladium, mercury, nickel, and iron. And besides, Hall's phenomenon has been observed with a goodly number of gold-silver alloys.

C. RESEARCHES ON RADIOACTIVITY.

Great interest attaches to investigations of the effect of low temperatures on the radiations of radium. Such work has been done at Leyden by Madame Curie and Prof. Onnes. The apparatus and methods, interesting as they are, must be passed over to state the results, namely, that in cooling radium to −253 deg. Cent. it has not been possible to note any change in the intensity of the gamma rays, even with a precision of measurement of 1/1,000.

D. RESEARCHES ON MAGNETISM.

The study of magnetism has entered into a new phase since Langevin conceived the idea of developing an electronic theory of paramagnetism and of diamagnetism, and Weiss has extended his hypotheses to the ferro-magnetic phenomena, introducing the idea of a molecular field, and has discovered the elementary magnetic moment, the "magneton."

Let us omit here the phenomena of para and ferro-magnetism. According to Langevin, the molecules of paramagnetic substances contain elementary magnets of constant moments. Molecular agitation by heat opposes itself to the uniform orientation of the molecules, and, admitting that the rotational energy of the molecules is proportional to the absolute temperature, it results from the theory of Langevin that the specific susceptibility (attraction per gramme for a field equal to unity) is inversely proportional to the absolute temperature. This is the law of Pierre Curie applied to paramagnetism.

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[1] Since this was written, Prof. Onnes has been able to prove that at a temperature of nearly absolute zero no resistance whatever is offered to a current in a conductor. Prof. Onnes's report on this matter appears on another page in this issue.—Editor of SCIENTIFIC AMERICAN SUPPLEMENT.

Weiss's molecular field is the name given to certain mutual actions of magnetic molecules, the origin of which is not known, but which are much stronger than any exterior field practicable with electromagnets which present saturation phenomena. The study of saturation is particularly interesting at very low temperatures.

It is for this reason that Prof. Onnes, in collaboration with Weiss, has determined magnetization to saturation at the temperature of liquid hydrogen for iron, nickel, cobalt, and magnetite. The results obtained have furnished to Weiss all that was lacking for the discovery of the magneton and for the computation of its size. For by dividing the magnetism-saturation by the number of molecules per unit-volume one obtains an elementary magnetic moment. Weiss has thus been able to show that all the molecular moments are multiples of an elementary moment, that is to say, of magnetons. The elementary magnet of iron contains eleven magnetons, and that of nickel three.

It will be understood from what precedes that the researches on the exceptions to the law of Curie are of high importance for the hypothesis of Langevin and for the magneton of Weiss. It is possible to compute the number of magnetons in any substance after a determination of its susceptibility to a given temperature, if the substance obeys rigorously the law of Curie. But this is often not the case.

Oxygen, the only gas which presents a fairly large paramagnetism, and already studied by Curie at high temperatures and pressures, is particularly interesting because it can be observed under the three conditions, solid, liquid, and gaseous. In the gaseous state it obeys the law of Curie, although as liquid or solid it presents considerable departures therefrom. An interesting fact is that in diluting oxygen with liquid nitrogen, a body nearly indifferent from the magnetic point of view, it has been found that the specific susceptibility of liquid oxygen is not only a function of the temperature, but also of the number of molecules of oxygen contained in a unit of volume.

The principal results found thus far with reference to other substances are that crystallized sulphate of gadolinium follows the law of Curie down to —259 deg. Cent. and similarly, the phenomena of saturation in ferric sulphate have been observed to low temperatures. It would appear, therefore, as if there had been found here a substance paramagnetic at ordinary temperatures and ferromagnetic at the temperature of liquid hydrogen.

Although it has been necessary to pass over a number of matters, the reader will have a fair idea of the different researches undertaken at the Cryogenic Laboratory at Leyden, and the theoretical questions there considered. When one realizes that Prof. Onnes has taken the initiative in these researches, that he is the intellectual father of the greater part of the investigations here described, one will rejoice with all those who have worked beside him in the distinction that has come to him from the Academy of Stockholm, distinction which, in addition, is sanctioned by the whole scientific world.

On the Persistence in Superconductors of Electric Currents Without Electromotive Force*

By H. Kammerlingh Onnes

The time of persistence of a current once established in a circuit, and then left to itself without electromotive force, is ordinarily extremely short, but for circuits in superconductors it can become so great that the current is practically permanent. This is the result of a computation based on data which the study of superconductors has furnished. I have just confirmed this conclusion by experiments which on their side lead to facts which may be reached by still another way. Let us review what has become known about the properties of superconductors.

In studying the resistances of metals at temperatures that one may obtain with liquid helium, I foresaw that the resistance of mercury would still be easy to measure at 4.25 deg. Kelvin, but would diminish so as to become negligible at 2 deg. Kelvin (—271 deg. Cent.). Experiments have verified this prediction so far as low temperatures are concerned, but at the same time have brought to light the fact that the disappearance of the resistance is sudden. The mercury at the temperature of the fall, here termed critical temperature (4.19 deg. Kelvin), passes in a disconnected way into a new state that is characterized by an extreme mobility of electricity. It may be well to term this condition, in which it is possible to maintain currents without appreciable electromotive force, the state of superconductivity. Into a thin thread of mercury 1 meter long at 1.7 deg. Kelvin I have been able to pass a current of the current density of about 1,000 amperes per square millimeter without an appreciable difference of potential at the two ends (limit of precision being 0.03×10^{-4} volt) and without developing there, in consequence, any trace of heat.

On dividing the difference of potential limit by the current, I have come to an upper limit of what I have provisionally termed the "microresidual resistance" of the superconductor.

For the metallic thread of which I have just spoken, it is the billionth part of its resistance at ordinary temperatures. The condition of superconductivity is not limited by temperature alone; current density is also a factor. For each temperature there is a critical density, different probably for the different conductors, below which there is no appreciable difference in potential. Above this density, as has been shown by wearisome analyses, there is developed a resistance of the same nature as that which is established when one passes the critical temperature, which I have termed "ordinary resistance."

This ordinary resistance, extremely weak at first, gives way at the first appearance of the differences of potential. The increase in temperature by the Joulean heat which is disengaged presently invades the whole conductor, so that differences in potential of the two ends, so soon as they appear at all, grow very fast with further increase of the current.

The critical density is very small at temperatures below the critical temperature, but it becomes very considerable when one works at temperatures notably lower, so that one can charge a circuit at these temperatures with a fairly strong current without its losing its character of superconductivity. Such circuits approach the circuits without resistance that Webber has introduced in his explanation of diamagnetism. With them it is possible to explore the vast field for experimentation to which the investigator is conducted by placing in the equations of electrodynamics a resistance infinitely small, or by admitting that the free course of the electrons is of the order of one meter. But the making of apparatus for experiments with mercury is difficult. It is fortunate, therefore, as was developed later, that tin and lead also become superconductors. The critical temperature of tin is 3.8 deg. Kelvin, and that of lead, probably 6 deg. Kelvin.

To study the application of superconductors to the production of intense fields—a problem of great difficulty on account of the disengagement of Joulean heat within very small spaces—I made a coil of 1,000 turns of lead wire, the section of the wire being 0.1 square millimeter, rolled into the thickness of 1 centimeter, and with a width of 1 centimeter. A current of about 0.8 ampere was passed into the coil without having had need of electromotive force to maintain it. There was no measurable development of heat. I had first considered provisionally the construction of an electromagnet of modest dimensions without iron, after Perrin, which would give a field of 100,000 gauss without developing a single joule. But here the investigation brought to light a new and highly interesting property of superconductors which makes such application impossible. The field, still inactive at values which were attained in our coil, as soon as one passes a certain critical field (1 kilogauss for lead at 1.8 deg. Kelvin) develops quickly enough the ordinary resistance in a superconductor, giving rise to heat due to the magnetic field. This critical field increases on passing below the critical temperature. It is important, therefore, when experimenting with a conductor that is exposed to a field (exterior or its own) to remain below the critical field.

Returning to the coil of lead wire at 1.8 deg. Kelvin, it is this which served me to demonstrate the persistence of currents without electromotive force in superconductors. Its coefficient of self-induction is 10^{6} C.G.S. with a current of 0.6 ampere (one cannot go below 0.8 ampere, for there it has been found higher than the critical intensity); its electrokinetic energy is then considerable, to be exhausted but slowly so long as there is not introduced into the circuit an ordinary resistance, which, however small, would absorb it in a short time. The total flux of the coil in a field of 200 gauss, much below the critical field determined above, is 0.6×10^{6} C.G.S., and suffices to establish a current of 0.6 ampere by induction.

The two ends of the circuit having been soldered together in the oxy-hydrogen flame—this by experiment being known to be a superconductive joint—the microresidual resistance of the coil was found to be less than one twenty-billionth of its resistance (736 ohms) at ordinary temperature. The time of persistence calculated by these elements is to be expressed in days.

Experiment has verified the computations. The coil inclosed in the cryostat was refrigerated in a field of 200 gauss from 0 deg. Cent. to 1.8 deg. Kelvin. In the superconductor circuit obtained in this way without current, a current giving it a paramagnetic moment developed itself when the field was moved away. The needle of a compass near the cryostat showed a strong disturbance when the coil was turned about a vertical axis. The coil acted like a permanent magnet, or rather a molecular current of Ampère. The moment measured by repeating its action on the compass with a coil of known current from previous tests indicated a current of from 0.4 to 0.6 ampere for hours in the superconducting coil. The precision of measurements under these extraordinary circumstances was not great. It did not permit of the measurement of any weakening. It has been possible only to indicate the higher limit. A decrease has been noted only at the beginning of an experiment and once again in connection with the return to a higher temperature. Leaving out these instances, as well as other peculiarities which demand later elucidation, it is possible to assert provisionally that the loss does not surpass 1 per cent an hour. In taking the coil from the temperature of liquid helium so that it could be raised above the critical temperature of lead, the phenomenon disappeared.

Control experiments were made by placing the plane of the coil parallel to the field. This gave unexpectedly an effect which was only about one eighth of the principal effect, and this was found again in experiments with the coil circuit open.

Further experiments have been tried with the coil in the first position and always refrigerated. A field smaller than the critical one was applied, and then, after some time, the field was withdrawn. The diamagnetic current resulting from the first operation was destroyed by that resulting from the second. There has been found an insignificant residue. Then a field capable of inducing twice the critical current was applied, and after a time, removed. The diamagnetic current of the first operation has been able to persist only when its intensity was reduced to the critical one. The second operation, after having nullified the persisting current, has produced on the disappearance of half the field which then remained a paramagnetic current about equal to that obtained in the previously described experiment. A very strong field applied in the same way has given the same result.

All these facts agree and leave no doubt about our having deduced properties belonging to superconductors. But it is interesting to have arrived at the superconductivity phenomena of lead refrigerated in helium in another way, an independent one, proving that the cause of the magnetic moment of the coil is indeed the current that circulates in it. To test this the two connections of a ballistic galvanometer were applied to the right and left of the soldered joint and close to it. Establishing the current in the coil as in the first experiment, and having placed the compass showing that the coil had a persisting moment, the joint was cut and the current observed to flow into the galvanometer (in which it was extinguished instantly), and at the same time the compass needle returned to a deviation corresponding to that moment which had been found in the experiment with the circuit of the open coil.

All this is suggestive of the idea of frictionless mechanics that Maxwell invented, completed to-day by the conception of electrons, which present themselves in very real fashion in these experiments. The electrons continue to circulate without electromotive force, and the rings, endowed with inertia, which in the hypothesis of Maxwell turn in the ether, continue to turn indefinitely. The smallest ordinary resistance introduced into this mechanism brings it most suddenly to a stop.

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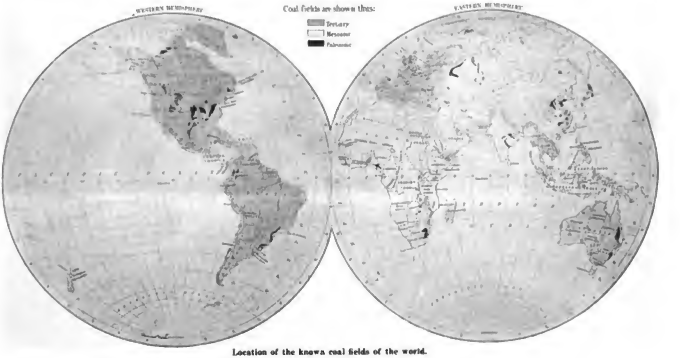
*A note presented by Prof. H. Kammerlingh Onnes to the Academy of Science through A. d'Arsonval at the meeting of June 29th.

An Automatic Mercury Pump

The *Journ. de Physique* describes a mercury pump that differs from older ones of the same type in that the gases instead of being evacuated directly into the atmosphere are evacuated into a canal system connected with a column of water and, in place of the displacements of the mercury being produced by displacements of the receiver, they are produced by the fact that the latter is put in communication alternately and automatically with the atmosphere and with the column of water by the action of a suitable arrangement. Diagrams are given showing the connections of the parts, and the method of working, together with the rate at which the gases are removed, are dealt with in detail.

Twenty States have published reports of their wood-using industries.



Location of the known coal fields of the world.

Coal and Its By-Products—II[1]

How and of What Coal Was Formed, and Some Account of Its Utilization

By Louis Cleveland Jones, Ph.D.

Concluded from Scientific American Supplement No. 2016, Page 118, August 22, 1914

NATURAL BY-PRODUCTS OF CARBONIZING ANCIENT VEGETATION RESIDUES.

Since commercial carbonizing of coal gives the benzene series of products, and not paraffines as existing in petroleum and natural gas, efforts have been made to explain the origin of natural gas and petroleum from animal remains, and Moissan has suggested the carbide theory. We believe, however, that the slow distillation of coal at low temperatures is a more logical explanation.[3]

Industrial experiments recently carried on in England upon low temperature distillation by the Coalite process, and more recently on coking coals at even lower temperatures, and *in vacuo*,[4] indicate that petroleum products identical with those found in nature are thus obtained.

In duplicating nature's conversion of bituminous coals to anthracite, the modern by-product oven, operating at a temperature of 1,000 deg. Cent. or more, does the work of ages in a day, producing coke the equivalent of natural anthracite, and, in place of natural gas and petroleum, illuminating gas and oils of the benzene series.

In the electric furnace we convert coke into graphite, and Moissan has converted graphite dissolved in cast iron into the diamond, the end of the series. But at these high temperatures, as stated before, the by-products are largely of the benzene series, while nature's by-products are of the methane series.

LOW TEMPERATURE CARBONIZING EXPERIMENTS.

Recently, therefore, in our laboratory at Syracuse, we have tried to determine the nature of the products at low temperatures, starting with the wood and going through the series to coke.

Our experiments are still incomplete, but some of the results are tabulated below. For example, wood, brown lignite, black lignite, Illinois coal, Kanawha gas coal, smokeless coal and anthracite were gradually heated until decomposition started and a small part of the gas was driven off. The results are calculated to the pure, dry coal basis.

In these experiments we used a cast-iron bomb, heated electrically or in a muffle furnace. This bomb, with absorbing apparatus and gas holder, was devised by the writer about eight years ago, and has been much used in the laboratories of the U. S. Government, and in our laboratories, for determining the nature and amount of products from various coals under varying conditions.

	Wood.	Brown Lignite.	Black Lignite.	Illinois Coal.	Kanawha Gas.	Smokeless.	Anthracite.
Analyses (per cent):							
H_2O and volatile	75	70.5	65.0	42.0	29.0	20.0	7.9
Fixed carbon	25	29.5	35.0	58.0	71.0	80.0	92.1
Temp. decomposition (deg. Cent.)	150	230	260	300	330	330	340?
Temp. range of expts. (deg. Cent.)	130–185	230–320	260–340	300–330	300–360	330–400	230–475
Litres gas evolved from 500 gms.	43.5	10.8	14.0	11.5	14.0	9.3	4.6
Cubic feet gas per ton	3,080	750	1,000	815	1,006	659	326
Gas analysis (p. c.):							
CO_2	58.6	55.6	40.3	24.1	7.3	6.5	10.3
C_2H_4	0.5	0.6	0.9	2.8	0.5	2.6	1.3
C_2H_6	0.0	1.0	0.8	2.2	1.4	2.3	0.4
CO	35.0	24.7	19.5	10.6	6.0	4.1	2.6
CH_4	1.3	11.4	19.5	43.3	57.4	53.5	70.8
H_2	1.0	0.3	0.0	3.4	14.6	9.7	0.0
N_2	3.0	6.4	10.0	13.6	12.8	21.3	14.8
Per cent by weight volatilized	51.0	26.8	31.0	23.7	12.2	10.0	0.7
Analysis of residue:							
Volatile	56.0	39.0	30.8	23.3	18.7	13.9	7.1
Fixed carbon	44.0	61.0	69.2	76.7	81.3	86.1	92.9

The residue from the first carbonizing test on the brown lignite was again heated from 450 to 500 deg. Cent., producing 3,500 cubic feet per ton of gas of analysis as shown under heading "A."

This second residue, heated again to 920 deg. Cent., gave 7,000 cubic feet of gas of analysis under heading "B."

	"A" Per cent.	"B" Per cent.
CO_2	27.2	7.0
C_2H_4	5.5	1.2
C_2H_6	3.2	1.1
O_2	.7	.5
CO	9.2	22.5
CH_4	38.4	18.3
H_2	12.0	41.8
N_2	3.8	7.5

Evidently from these tests decomposition gradually brought about by heat tends to drive off at first the high oxygen content, and each coal type is converted into a type similar to, though not exactly like, the succeeding higher grade fuel.

In the case of wood, the gas first evolved contains about 97 per cent of CO_2 and CO. Similarly the lignites and Illinois coals first give off a high percentage of oxygenated compounds, and in this way necessarily the residues contain less oxygen and are of higher calorific value.

Under high pressures doubtless a sharper fractional decomposition would result, and the residues even more closely resemble the natural fuels.

At any rate, such slow, artificial carbonization is strikingly suggestive of nature's process. These residues show decided resemblances to the natural product. That they are not identical, both physically and chemically, may be due to the high pressure used in nature which we have made no effort to duplicate.[5]

NATURAL GAS A BY-PRODUCT OF COAL.

But if natural gas, chiefly methane and hydrogen, is a by-product of nature's carbonizing processes, we must explain the disappearance of the large amount of carbon dioxide and carbon monoxide which was originally present in such decomposition gases. May we not assume that the CO_2 has been absorbed from the gas by the alkaline earth waters produced by weathering rocks, and that the carbon monoxide has been absorbed and oxidized by metallic oxides?[6] Gas thus obtained from carbonizing lignite, for example, by removal of CO_2 and CO would be practically identical with natural gas. Thus, calculating out the CO_2 and CO from the gas obtained in heating lignites at low temperatures, we have left a gas containing principally methane, i. e., a typical natural gas.

CLASSIFICATION OF COALS.

Now that we understand the nature of coals as different residues in the progressive decomposition of wood into graphite, we are in a position to classify them. Rejecting accidental impurities, such as ash and sulphur, and using the pure coal basis, coals may be classified in several ways. Five important differences are suggested on the following chart as bases of classification; for example, moisture, volatile, oxygen content, calorific value, and finally, initial decomposition temperature. Specific gravity, total carbon, oxygen content, and other characteristics might also be given, all of which indicate the same progressive change in characteristics.

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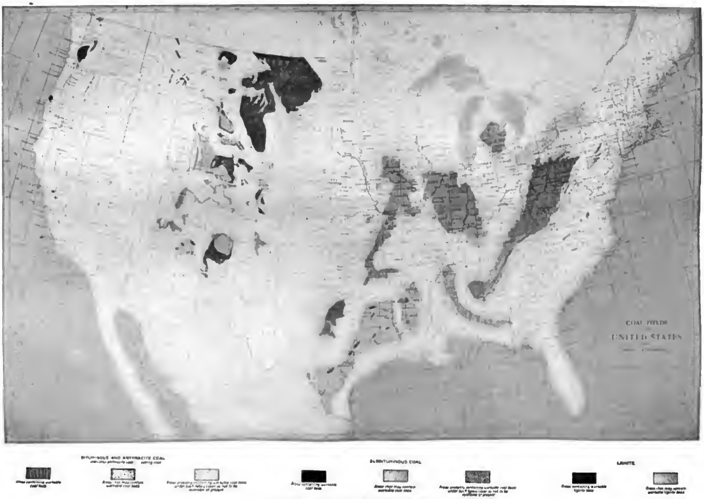
[1] Presented at the meeting of the Section of Physics and Chemistry of the Franklin Institute, and published in its *Journal*.

[3] Mabery's study of "Mahone Petroleum, Its Recent Origin and the Origin of Petroleum in General," has just come to my attention. The evidence given leaves little doubt that petroleum is one of nature's by-products of coal.—*J. I. and Eng. Chem.*, February 14th, p. 101.

[4] Pictet & Bouvier, Ber., 1913, p. 3342.

[5] Results obtained by Ralston, U. S. Bureau of Mines, when plotting the composition of coals by the ingenious triangle method, indicate that the curve of decomposition bends strongly as semi-anthracite is approached, corresponding to the bend in our curve for calorific value of volatile matter.

[6] It is well known that CO in the presence of hydrogen can be oxidized to CO_2 without attacking the hydrogen by passing over metallic oxides. This selective oxidation is possible with ferric oxide and with copper oxide. Temperatures as low as 250 deg. Cent. are sufficient.



Distribution of coal in the United States.

BETTER STANDARDIZED ANALYTICAL METHODS REQUIRED FOR VOLATILE MATTER AND MOISTURE.

Unfortunately it is necessary to call attention to the lack of uniformity in methods of determining moisture and volatile matter in coals, since much of the data given in the tables presented depends in particular upon consistent results in the determination of these figures.

An atmosphere standing over a calcium chloride solution containing 35.5 per cent anhydrous chloride will show a test at any ordinary temperature of 50 per cent relative humidity. Likewise atmosphere in equilibrium with calcium chloride solutions will have the following relative humidities:

Calcium chloride. Per cent.	Humidity. Per cent.
26	60
12	40
20	50
30.5	30
35.5	70
41	90
45	80

A coal in such an atmosphere will, like any other hygroscopic material, take up and hold a definite amount of moisture according to its position among the types of fuels shown on chart VI, bottom of this page.

Volatile tests can be made with much satisfaction by use of the Meker burner, but perhaps for strict comparison standardized conditions in a muffle furnace are better.

Evidently as we progress in the series, volatile matter, oxygen and moisture go down, while calorific values and temperatures of decomposition go up. As decomposition progresses the specific gravity also goes up.

I am not aware that the decomposition temperatures of coal types have ever before been studied, but since, as we have assumed, coals are residues representing the different steps in nature's carbonizing process under progressively severer conditions, it is only natural that they should have different, and, as we go up the scale, increasing temperatures at which they begin (again) to decompose. That these decomposition temperatures are progressively higher is a further strong indication that coals really are just such residues as has been assumed.

Low grade coals contain much moisture. They are, in fact, hygroscopic, and will, like other hygroscopic materials, when dried take up again moisture from moist air in proportion to its relative humidity.

As has sometimes been assumed, high volatile coals are not geologically new coals, nor are smokeless coals of an older geological formation, as is evident from the wide variations in volatile found in coals from the same geological seam. For example, the Pocahontas coals vary in volatile from say 16 per cent in the true Pocahontas district, to above 30 per cent in the equivalent geological New River district north of Meadow River, W. Va.

Though coals were formed from vegetation at the beginning of the carboniferous era, in the presence of more carbon dioxide in the air than later coals, this does not seem to have been the cause of any real difference in their character.

The classification, however, of coals on the basis of temperature required to decompose, is rational, as is strikingly shown from a study of coal deposits everywhere. In Washington State there are coals of all types from lignite to graphite, and, under different conditions, all types may be found in what appears to be the same geological horizon. When the seam is horizontal the coal is lignite; when somewhat disturbed and oblique the coal is generally a gas or smokeless coking coal; when folded it becomes anthracite, and finally, when pierced by igneous rock, we have graphite.

COKABILITY.

In commercial work for our purposes coking coals have also to be classified as to cokability. In the following

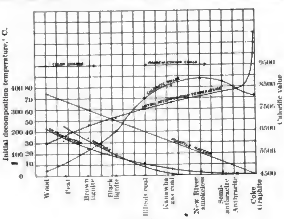


Chart VI.

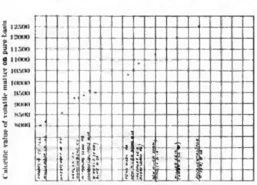


Chart VII.—Table showing calorific value of volatile matter for typical coal fields of the United States.

manner, which really is based upon oxygen content, though not requiring the tedious ultimate analysis necessary to give oxygen content, we have classified coals as to cokability, using as a basis the calorific value of the volatile matter contained. This, for coals of the same percentage volatile content, fairly represents cokability in actual coke-oven practice.

On chart VI (page 133) the range of possible coking coals was indicated. Now, by deducting the calorific value due to fixed carbon (calculated) from the total calorific value, and dividing by the amount of volatile matter, all on the pure basis, we get a series of coals of increasing cementing or coking tendencies.

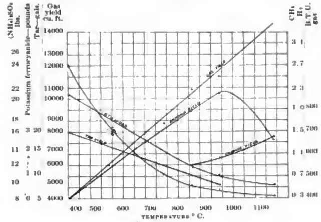


Chart VIII.

As shown on Chart VII, this variation in calorific value of the volatile matter has been found to represent results in actual coking practice.

As the calorific value of the volatile matter increases the cokability increases up to the point where the actual amount of volatile matter becomes insufficient to cement and hold the mass together. For example, semi-anthracite coals and anthracite, as to cokability, are beyond the limiting factor of insufficient cementing volatile material.

Cannel coal is unusual in that the calorific value of its volatile matter is higher than for any other coal with volatile so high. By the Ralston method of classifying and plotting it falls well above the usual curve.

Coals also differ as to the amount of materials contained capable of solution in caustic, pyridine, benzene and other solvents, and may be classified accordingly. So the residues from artificial carbonization at low temperatures give different amounts of matter soluble in the various solvents.

Finally, on exposure to moist atmosphere, coals decay. They become oxidized and go back in the series. For example, by taking up oxygen and water a good coking coal takes on the character of a poor sub-bituminous coal or of the qualities of the non-coking lignite.

Coals, and their by-products, are therefore not such mysterious materials. They are merely intermediate bodies resulting from the decomposition of ancient vegetation, just as a multitude of substances may be obtained by violent or gradual decomposition with heat of any simple organic compound.

COMMERCIAL MANUFACTURE OF COKE AND BY-PRODUCTS.

The conversion of bituminous coking coal to its anthracite-graphite equivalent, coke, has become of extreme commercial importance, and particularly when this is done with the recovery of the by-products. A ton of average coking coal will produce in the modern by-product oven:

1,500 pounds coke.
18 to 26 pounds sulphate of ammonia.
6 to 10 gallons tar.
1¾ to 2¼ gallons mixed light oils (benzole, toluole, xylole).
1½ pounds ferrocyanid.

By further elaboration, from these light oils and tar practically all the compounds mentioned in Beilstein may be produced.

On Chart VIII is indicated the influence of temperature upon the yields and character of the by-products obtained from an average coking coal. The temperatures given represent the hottest part of the retort at the beginning and end of the carbonizing period. The average temperature would be considerably lower.

On this chart the yield of light oil is not given, but our experiments indicate a maximum yield of this material at about 500 to 550 deg. Cent.

VIRGIN COAL FIELDS IN THE UNITED STATES.

With this article are given some pictures selected from photographs taken by the writer to illustrate conditions in the virgin coal fields of the United States. These good Americans, with conditions of living which the discoveries of Koch and Pasteur have not yet reached, represent a backward glimpse into the frontier life of our own colonists' forefathers; this log cabin, timber clearing, horseback, spinning-wheel life, with its quaint Shakespearean dialect, is rapidly passing. A permanent record of some of these things is, therefore, of scientific value.

The "Britannia" Airship

By Major Bannerman-Phillips

A FUND is being raised in Great Britain by public subscription to build and present to the government, if it is found suitable by the naval authorities, a new type of dirigible to be called the "Britannia" airship. It is the invention of Mr. J. Wulfing, an ingenious nautical engineer. The method which will be employed in maneuvering is that of Mr. A. de Bajza.

The chief point in the construction is the method of building up the aerostat, which combines the advantages of the rigid type as regards protection of gas containers, maintenance of shape (even when gas is lost) and facility of steering with those of the non-rigid type in that it can lie flat when deflated, and this is the chief factor in insuring a far greater net lifting power than is possible with any other known type of airship.

The hull is built up of longitudinal steel tubes *a*, suitably braced together, having their ends fixed to metal nose-pieces at either end. A central steel cable runs from bow to stern and braces the whole structure, making it perfectly rigid. The structure, or framework, is suitably covered with fabric. The inside may be divided into partitions, thus preventing complete loss of gas if punctured.

The base of the aerostat is left flexible by the omission of two or more steel tubes (in this case 3), whose place is taken by elastic strands. When the gas expands or contracts, owing to atmospheric changes, the increase or decrease in volume is taken up by the loose belly thus formed; this prevents loss of gas when expansion takes place. This belly is contained in a covering by which the car is suspended from the aerostat.

This covering forms an air channel which has no opening at front and rear *k*, through which the front propeller drives a current of air, thus removing any loose gas which may otherwise have collected. The necessity for this, or some similar arrangement, was pointed out in the SCIENTIFIC AMERICAN of November 22nd, 1913.

The engines are six in number, three of which are mounted at the front, and three at the back. In front is one central motor *b*, while just behind it are two others *c*, carried on outriggers which extend upward at the sides of the aerostat. A similar arrangement, in reversed order, is adopted at the rear.

The motors are so placed that the center of propulsion coincides with the center of resistance as nearly as possible.

As the propellers are directly coupled to the motors there is no loss of energy due to transmission. This means more propulsive power than stationary engines, giving the same nominal equivalent in horse-power; in fact, an increase of approximately 20 per cent. The propellers and car are so arranged that landing can be effected on either land or water without fear of damage.

The front and rear motors are so constructed and so fixed as to be capable of being tilted up and down and swiveled right and left to aid in steering; this is especially important when ascending from or alighting in a limited space, as it allows the airship to be turned about in its own length.

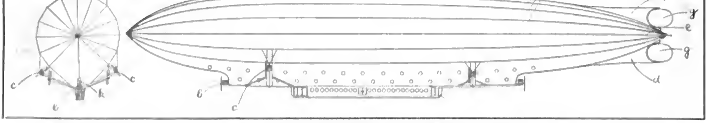
At the rear of the aerostat are two vertical stability planes *d*, and at the rear of these again are two rudders *g* for horizontal steering, which are pivoted one third of their distance from the front. This arrangement insures ease and efficiency of control. There are also two horizontal stability planes *e*, which have elevating planes pivoted in the same manner as the rudders.

The following are the main dimensions and particulars as regard the airship:

Length	340 feet
Maximum diameter	52 feet 4 inches
Average diameter	40 feet
Capacity	350,000 cubic feet
Gross lifting power	29,325 pounds
Total weight, with car and engine	16,670 pounds

As the total lifting power is 29,325 pounds and the total weight is 16,870 pounds, the net lifting power is 12,655 pounds, or 43 per cent. This compares very favorably with the Zeppelins, which have a net lifting power of only 28 per cent; thus, Mr. Wulfing's airship has 53 per cent more net lifting power than the Zeppelins, but if of the same size, the net lifting power would exceed that of the Zeppelins by about 85 per cent.

This high efficiency as regards net lifting power is obviously an enormous advantage, since it means that more actual weight can be carried in the shape of fuel, cargo, ballast, passengers, wireless telegraphy apparatus, or explosives. In time of war, when the airship might have to remain aloft for long periods, it would enable the vessel to carry a crew sufficiently numerous to work in reliefs, or to transport ammunition rapidly when urgently wanted, say in a beleaguered fortress, or to renew the exhausted supplies



a are longitudinal steel tubes; three of these tubes are omitted at the bottom to provide room for an elastic belly which swells out as the gas expands. Loose gas is driven out of the covering in which the belly hangs by a propeller.

The "Britannia" airship.

of a detached force over the heads of an intervening enemy.

The Zeppelin vessels are the most successful rigid dirigibles up to the present. Taking them as a standard, Mr. Wolfing's airship compares very favorably in the following points:

Although it is absolutely rigid, the construction is so light that if it were built of the same capacity as the Zeppelins, with double the size of car for passengers, and larger fuel containers, it would still have 80 per cent to 90 per cent more net lifting power than the latter.

The higher efficiency permits of an increase in speed up to 55 or 65 miles per hour.

The higher net lifting power enables the dirigible to take in more fuel for a longer radius of action in time of war.

On the "Britannia" airship quick-firing guns, with ample supply of ammunition, a larger crew, wireless apparatus, etc., can be carried.

For civilian use, a good income could be earned by passenger carrying and displaying advertisements, illuminated at night.

If gas were lost or a high altitude desired, 25 per cent of the total weight of the ship could be sacrificed in ballast or fuel, owing to the high net lifting power.

A sacrifice of 25 per cent would give an additional altitude of about 7,000 feet, and a further altitude up to 12,000 feet could easily be obtained by tilting the nose of the ship up a few degrees from the horizontal and driving at full speed; if the bow and stern motors themselves were tilted upward a few degrees, this of itself would give additional lift.

Mr. Wolfing's airship, of the above-mentioned displacement, would have a speed of 55 to 65 miles per hour, and a radius of action of 800 miles, or it could make a single voyage of 1,000 miles without taking in fresh supplies of fuel.

Apart from the above advantages, the one of cost is very considerable.

The cost of an airship, equal in size to the Zeppelin, would be $75,000, as compared with $165,000 of the latter. The cost of the "Britannia" of smaller size, with greater efficiency than the Zeppelin, will not exceed $50,000.

Aerial Reconnaissance During Sieges*

Its Important Influence on Artillery Attack and Defense

By E. Kabisch

Not many years ago the search for masked batteries was confined to howitzers and mortars. Field guns were always placed on heights, from which the eye of the gunner could follow the quick movements of the infantry and cavalry, and discover the approaching artillery of the enemy before it had come within firing range. It was supposed that the introduction of the gun shield would increase the effectiveness of this open method of warfare.

The experience of the Russo-Japanese war brought forward advocates for the masking of field pieces, but this suggestion was violently opposed at first. I remember that a division commander who had risen from the field artillery said to me, in discussing the maneuvers in 1906: "I should not like to show my division the spectacle of artillery hiding behind hills." But the advocates of concealment prevailed and soon it became necessary to remind the artillery that the exigencies of battle might eventually require it to break cover and come out into full view of the enemy.

The foot artillery still more eagerly adopted the employment of concealed positions, and greatly developed their possibilities by improving methods of aiming and observation. The destructive action of modern heavy artillery is so great that a battery once discovered by the enemy appears doomed to speedy annihilation. These arguments apply still more forcibly to sieges, in which victory, for either combatant, depends mainly upon his ability to unmask the enemy's batteries and conceal his own. In this contest the advantage that the besieged can derive from thorough exploration of the ground in time of peace, is partly counterbalanced by the wider expansion of the besieging forces and their ability to utilize every possibility of the ground.

Aerial reconnaissance has long been employed both in sieges and in the field. Until recently reliance was placed mainly on captive balloons, although the use of free balloons, to a limited extent, in sieges, was also advocated. No extravagant hopes were entertained in regard to the captive balloon. It presents so excellent a mark for artillery fire that it cannot be used within the range of shrapnel, and its ability to discover small objects is slight, especially in the foggy climate of Europe. The free balloon, sent up by the besiegers to float over the invested fortress and to photograph its details, must also float very high, in order to escape destruction, and the objects photographed are largely determined by chance. The free balloon is of still less value to the besieged, because it is impossible to bring it and its photographs back to the fortress. In open campaigns no attempt has been made to use free balloons for reconnaissance.

The development of the airship, and especially of the aeroplane, is rapidly bringing about a complete revolution in aerial reconnaissance. It can be a question of only a few years before the progress of aviation will make it possible to discover every battery in the field. This development leads inevitably to the construction of aerial battleships, fitted to attack and destroy each other.

In the field both combatants will be able to employ aerial fleets, but these will be exposed to attack from land batteries, as well as from each other. This fact and the shortness of the time available for reconnaissance will enable many batteries to escape possible detection.

In sieges the conditions are very different. It is *a priori* impossible for the defenders to contest the command of the air for any long period. In the first place, they will be poorly equipped with aeroplanes, which will be assigned chiefly to the field corps. The besieged fortress will be fortunate if it happens to possess a few serviceable machines and a few skilled aviators. This little aerial squadron will soon be destroyed by the vastly greater fleet of the enemy, and it will be impossible to replace it.

The superior claim of the field corps will prevent the sending of reinforcements to the aerial squadron of the fortress, and even if they should be sent, the incoming vessels would be in danger of being shot down by both friends and foes, as it is almost impossible to distinguish between aeroplanes in flight.

The fortress can train its guns upon the aerial scout of the enemy and seriously hamper him in his work of aerial reconnaissance, but it is obvious that the development of aviation has given the besieger a great advantage. Telephotographic views, taken from his aeroplanes, will reveal defending batteries lurking behind hills, and if expert artillery officers are placed on the areoplanes as observers, the prospect of speedy destruction of the unmasked batteries become at once very favorable.

For averting this discovery and destruction there are only two means—the gun shield and the mask of trees. The gun shield cannot escape the eye and the camera of the aviator, but its destruction requires such accuracy of fire that the mere knowledge of its location, even if laid down correctly on a plan, by no means decides its fate. Its systematic destruction requires either accurate lateral observation or a great expenditure of very costly ammunition.

This most efficient protective device, however, is itself so costly that it can be employed only to a very limited extent. Moreover, the gun so protected is fixed to one spot. It cannot be moved from a part not attacked to a place where it is most needed, and it cannot be used by a besieging force.

Masks of trees, if properly arranged, present very serious obstacles to aerial reconnaissance. A few narrow lines of trees will not suffice; numerous irregular groups are necessary. For this reason large orchards, distributed among meadows and cornfields, are very effective. Where this method of cultivation is customary, as it is in Alsace-Lorraine and Baden, the free distribution of young trees and the offer of prizes for their cultivation would induce farmers to plant orchards on their own land. In this way the cost of acquiring land for this purpose would be saved to the military administration—provided that it was supported willingly, skilfully, and discreetly by the civil authorities. This method is a slow one, as years would be required to produce sufficient protection for artillery. For this reason this inevitable development should be begun without delay.

The adoption of these protective measures is only part of the defender's task. He will be compelled, more than ever before, to seize in advance all commanding heights near the fortress, in order to observe the enemy without the aid of aeroplanes, and to assure free scope and long range for infantry fire. For if the defending batteries fail to escape discovery by the besieger's aerial scouts, and prove unable to sustain the combat with invisible enemies, their only chance of success lies in retreating so far that the enemy's siege guns cannot reach them without breaking cover and coming into view of the defenders.

At first sight this retreat appears to involve a sacrifice of the infantry, whose positions are now left without artillery protection and exposed to the fire of the heavy siege guns of the enemy. This exposure, however, is unimportant if the infantry positions are fortified so strongly that they can defy the attack of the distant siege guns. Only the attacking *infantry* can force the defenders to show themselves on the breastworks, and the attacking infantry cannot do this without exposing itself to the fire of the retracted artillery of the defenders.

Here we come to a tactical method that is often employed in the field—the so-called artillery cartel. The artillery of each side ignores that of the other and directs its fire on the infantry, which, as usual, pays the toll of blood. Yet the artillery of the besiegers cannot disregard its own infantry's cry for help, and is obliged to advance far enough to renew the attack upon the *retracted* defending batteries. This is the commencement of the decisive conflict, in which a very important part is played by the possibilities of cover afforded by the ground within a mile of the infantry positions of the defense. If the defending artillery can hold its own in this part of the fight, in which its chances are far better than in the initial engagement at long range, the attack of the besieger's infantry may be stopped.

This result cannot be accomplished unless the positions of the defending infantry are strongly fortified. If they cannot withstand the enemy's artillery fire they will be captured easily, without even compelling the attacking infantry to make a gradual and perilous approach.

The required protection can be given only by permanent fortifications, but these need not be storm-proof at every point. The character of the front and the foreground should be taken into consideration. Open ground, affording a view of the enemy's action, is in itself a great protection (even at night, with the employment of searchlights) and gives the retracted defending batteries free scope. Hence infantry cover, so situated, need not be absolutely storm-proof. But if the foreground affords the attacking infantry cover at short range, the positions of the defending infantry must be very strongly fortified in order to escape being taken by assault. The fortifications, therefore, should be adapted to local conditions, not constructed according to a uniform type, without regard to expense. They should always, however, assure ample protection to the men. Otherwise, in view of the limitation of the powers of the defending artillery by the development of aerial reconnaissance, the fortress will soon fall an easy prey to an energetic, systematic, and well equipped besieging force.

CONCLUSIONS.

The development of aviation has given the besieger an important advantage. In addition to the possibility of injuring the fortress by aerial attack (a point which is here purposely passed over), the artillery combat is influenced greatly to the disadvantage of the defense. The employment of gun shields cannot be much increased, hence the guns must be masked by trees, or otherwise, as well as possible. Furthermore, it must be understood that the defending artillery will soon be forced to retreat before the overwhelming fire of the hidden siege guns of the enemy, and that the decisive action will be the infantry attack upon the positions of the defending infantry.

If these positions are insufficiently fortified they will be quickly destroyed by the distant fire of the besieging artillery. If, on the contrary, they are bomb-proof, the attacking artillery will be forced to advance and endeavor to destroy the retracted batteries of the defense. In this second duel the unconcealed and unprotected attacking artillery will be in serious danger of annihilation.

It may be objected that I have overlooked the possibility of the employment of aerial scouts by the defense for discovering the enemy's preparations for attack. I doubt whether the defense would long remain in possession of an aerial fleet, which would be the first object of the enemy's attack.

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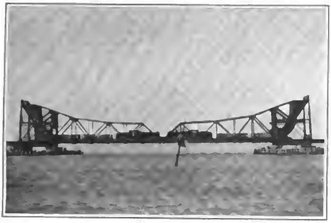
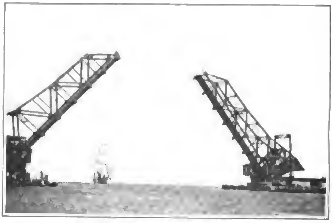
* Translated from *Militär Wochenblatt.*



The roller lift bridge with test load of locomotives and cars.



The bridge open for a typical sailing vessel.

Linking India and Ceylon by Railway

Difficulties of Bridge Construction With Native Labor

By F. C. Coleman

A DIRECT connection between the railways of India and Ceylon has lately been opened. This scheme comprised the extension of the South Indian Railway from Mandapam, on the mainland of India, to Danushkodi, on the island of Rameswaram; an extension from Madawachi, on the main line of the Ceylon Government Railways, to Taliemannar, on the island of Manaar; and the construction of two piers and customs, postal and railway quarters at each of the railway termini, for the service of the ferry steamers provided between them. In addition, a quarantine camp has been constructed near Mandapam for the detention of Indian coolie labor *en route* for Ceylon.

The most interesting work was the bridge construction across Palk Straits along the reef extending from the mainland of India to the island of Rameswaram. The structure, commencing from Ramen Point on a narrow sandy promontory called Toni Toral, about 2 miles from Mandapam, consists of 112 plate girder spans of 40 feet, one of 43 feet, a Scherzer rolling lift bridge of 289 feet, one plate girder span of 44 feet and 31 spans of 40 feet, extending to Pamban. At the Scherzer span, Pamban Pass, an artificial channel made some fifty years ago, provides for coastwise navigation. This is the only navigable channel between India and Ceylon, and has a depth of about 14 feet. The substructure for the Scherzer bridge consists of two 9-foot and two 12-foot cylindrical piers at each side of the channel, extending down about 45 feet below mean sea level into a stratum of stiff yellow clay. The cylinders on the Pamban side were sunk with an air-lock, but those on the Toni Toral side were sunk by dredge and divers. To facilitate the sinking of these cylinders two artificial islands were made of coral boulders and concrete in sacks inclosed within a timber caisson and covered with clay and sand.

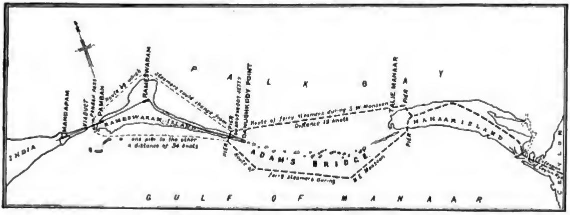
From an engineering standpoint the erection of the Scherzer bridge is of interest because native Indian labor was used solely, and because, to prevent interference with navigation, the leaves were erected in a position inclined about 60 degrees to the horizontal, despite the high winds and strong currents prevailing.

Hindu Temple at Rameswaram Island.

The bridge is of the double-leaf, through type, for single track of 3 feet 3⅜-inch gage, with a span of 225 feet between bearings, and a width of 20 feet between center lines of trusses. The erectors were Moplahs, who are natives of the Malabar coast on the western side of India. They were employed by two contractors, each of whom had been awarded the contract for the erection of one leaf and had previously erected the 40-foot girder span. The rivalry between the two crews, although not always friendly, did much toward expediting the completion of the bridge. The Moplahs did not have much previous experience of bridge erection, but were strong and active and skillful at rigging work. All other labor was employed directly by the South Indian Railway Company, and was composed mainly of Anglo Indians (Eurasians) and Tamils as foremen, engine men, mechanics, rivet inspectors, painters, and boatmen, in addition to the coolies of both sexes.

The average hours of work were about ten per day, and work was carried on continuously, on Sundays as well. Occasionally a Mohammedan feast day would stop the work. During the Mohammedan fasting period, which continued for thirty days from August 4th, work stopped at about 4 o'clock every afternoon. Then the Moplahs abstained rigidly from eating, drinking, smoking and chewing from sunrise to sunset, notwithstanding the climatic conditions, and even tried to abstain from swallowing.

Erection work commenced on July 20th with the drilling of holes in the anchorages for the anchorage column splices. The 12-ton track girders were then moved and hoisted into place by means of tackle and hand winches and a gantry or framework of teak poles lashed together, on each island which had been left standing after being used on the substructure work. Because of the small space on the islands, only a few pieces could be brought at a time from the storeyard at Toni Toral. The materials for each half of both leaves had been painted a distinctive color in addition to the erection marks, so that the most illiterate of the workmen could distinguish them. Riveting was performed by pneumatic tools, as well as the drilling and reaming necessary. The riveting done was a source of annoyance at first, due to the inexperience of the workmen, but as the work progressed the riveting improved, and



Map showing the new railroad connection between India and Ceylon.

they were able to drive the rivets at a rate of 250 a day per squad. When the fixed portions of the bridge had been erected and the segmental girders and some of the subsequent pieces placed and blocked up in their proper positions, the gantry poles used for erecting were removed and the counterweight boxes assembled. Riveting followed closely on erecting, and after completion of the counterweight boxes, forms of ⅜-inch teak wood for the adjustment pockets were put into place in the boxes by Indian carpenters from the construction workshop at Toni Torai. Though these carpenters, like the other Indian workmen, used tools and methods that do not wholly conform with English and American ideas, and had little knowledge of plans, their work was good. In one respect they have the advantage of being adepts in supplementing their handicraft with foot-craft. Stacks or cribs of old railway ties were placed to support the counterweight wings during the unbalanced condition of the leaves, and runways were built for placing the counterweight concrete. A concrete mixer of half a cubic yard capacity, mounted on a pontoon scow, moored at each island was used. As the batches of concrete were mixed they were dumped upon the deck of the scow and shoveled into galvanized iron dishes, about 12 inches in diameter and 5 inches deep. The concrete was carried up the runways in these dishes by the coolies, comprising young boys and women of all ages, and passed along to be deposited in the counterweight. In this way as much as 2 cubic yards per hour could be placed. While the concreting was going on the erection and riveting were also progressing. Two panel lengths of top chords for each truss, the adjacent web members and the machinery floor and bracing for each leaf were in place, when an erection derrick was assembled to rest on the top chords of the second panel. By means of these erection derricks the web members, chords, floor, and bracing members were hoisted up and bolted in place in logical sequence.

The first train across the bridge was run through on December 14th. In connection with this the Hindu belief in "inauspicious occasions" was brought up. According to Hindu religious chronology one of these occasions commenced at 4 P. M. on the 14th, during which any new undertaking would result in misfortune and disaster. Because of that, the work of track laying was continued throughout the previous night, so the first train was run across the bridge at about 10 minutes to 4, with no cause for misgivings on the part of the interested Hindu spectators.

As regular passenger traffic across the bridge has now commenced and a through service from the main line of the South Indian Railway to Danushkodi is inaugurated, the ferry service between Mandapam and Pamban, which previously served the immense pilgrim traffic—at times amounting to more than 30,000 passengers per day—has been discontinued.

Operator's house on the roller lift bridge.

The Thyroid and Thymus in Relation to Development

In speaking of growth or development, those who do not give close attention to the problems involved in this phenomenon usually emphasize primarily the increase in size or weight which familiarly characterize it. The growth of the organism as a whole, particularly at an early period, is accompanied by another feature, that of differentiation. The changes in form and weight do not consist merely of additions to the tissue elements already laid down, but frequently also include those alterations whereby new types of structure are added to or evolved out of the primitive ones originally present.

The striking experiments of Dr. Gudernatsch[1], of the Department of Anatomy at Cornell University Medical College in New York, lend a peculiar emphasis to the fact that in development we may deal with two entirely separate factors, one of growth and one of differentiation. This was brought out by feeding to developing tadpoles certain mammalian glands with so-called internal secretion. The results, which have now been abundantly verified, leave no doubt that the thyroid gland contains something which, when the gland is given as food, calls forth a rapid differentiation in a developing vertebrate organism. This may be brought about at any stage of development before maturity is reached. The differentiation may therefore be highly precocious if the treatment is begun on extremely young animals. For example, tadpoles could actually be brought to the point of metamorphosis within eighteen days after hatching, while normally they would require ten or twelve weeks to reach such a stage. The results of this premature metamorphosis are perfect frogs of minute size—pygmy frogs. The thyroid influence is very decided and no tadpole given a thyroid diet escapes from it. Each individual, even if thousands be employed, as was the case in several experiments, will react almost immediately to the thyroid stimulus, so that certain changes in its structure may be observed twenty-four hours after a single feeding of thyroid.

If thyroid is given to these differentiating animals too rapidly, they usually die very soon after the appearance of their fore limbs and the reduction of their tails; but if they are fed carefully they may be kept alive for several weeks. They will not undergo any further changes except perhaps a continued reduction of their tails, nor will they ever feed again after this differentiation. During this period of excited differentiation, curiously enough, the animals fail to grow. Though the thyroid induces differentiation to a degree not common to other foods, there is no evidence that it possesses any power to prevent growth to the morphologic changes. The suppression of growth may merely be incidental, for rapid differentiation does not allow growth.

The thymus, on the other hand, has the power to stimulate growth, but lacks that of exciting differentiation. Tadpoles feeding on any food (except thyroid) reach a maximum size, and thereupon differentiation begins independently. Thymus-fed tadpoles experience a rapid growth, but fail to be brought to metamorphosis within the usual period. They are slow to develop their hind limbs, even though they grow in size beyond the normal. The thymus, therefore, possesses a quality that suppresses differentiation in a way not exemplified by any other food used.

Whether or not other glands share in any degree the accelerating or the depressing power so conspicuously shown by those already described at length, cannot at present be positively answered. The pronounced effects produced in developing organisms by the thyroid and thymus, respectively, at once suggest inquiries of the most diverse character regarding the possible rôle of these organs in the development of the human individual. For the moment we must remain content to record these exceptional experiences which show how specifically our food factors may be related to developmental processes.—*Journal of the American Medical Association.*

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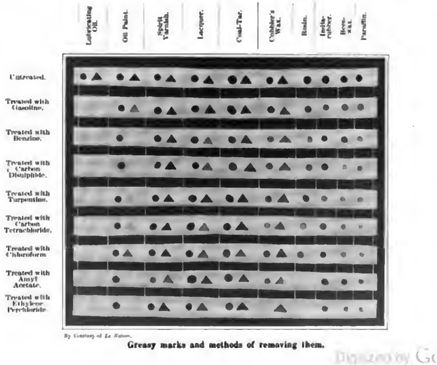
[1] Gudernatsch, J. F.: Feeding Experiments on Tadpoles I. Arch. f. Entwicklungsmech. d. Organ., 1912, xxxv, 457; II. A Further Contribution to the Knowledge of Organs with Internal Secretion. Am. Jour. Anat., 1914, xv, 431.

Preserving Eggs

When properly treated, preserved eggs are permitted by the officials responsible for food conditions in many States. One of the preserving methods that has given fairly good results is to carefully pack the eggs in a clean and well scalded keg, and cover them with a solution made up of one part commercial water glass (a solution of sodium silicate) in ten parts of water, well stirred. Eggs packed in this way and kept in a cool place will keep in good condition for six months or more. Sterile (infertile) eggs will keep much longer than fertile eggs. When preserved eggs are boiled they are liable to crack, but this can be prevented by pricking the blunt end of the egg with a pin before cooking.

Stains and Their Cures

The accompanying half-tone illustration requires little explanation. In order to find out the effect of any particular cleansing fluid on any particular kind of stain, look for the name of the liquid in the left hand column, and for the stain at the head of the table. A triangle refers to a fresh stain, a circle to an old one.—*Illustrated London News.*



By Courtesy of *La Nature.*

Greasy marks and methods of removing them.

The Principles and Theory of Mutation[*]

The Evolution of Species, Not a Slow Process, But Takes Place by Leaps

By Professor Hugo de Vries, of the Univerity of Amsterdam

Unity of internal structure combined with a great diversity of external forms is the great principle of organic differentiation. Lamarck was the first to point this out and to explain it by his theory of common descent. But the science of his time did not afford a sufficient body of facts in proof of his conception, and he failed to convince his contemporaries.[1]

It has been the work of Darwin to accumulate a large number of facts and arguments, borrowed from the most diverse parts of the physical and biological sciences, and to combine the main results of the study of nature in general in order to find a conclusive proof of the idea of Lamarck. Common descent is now acknowledged as the natural cause of the unity of organization. Successive slow modifications have produced the great diversity of forms and the diverging lines of evolution which have gradually led to the highest degrees of differentiation.

But his broad views and comprehensive considerations did not suffice to afford the desired proof. Comparative anatomy and systematical studies, the knowledge of the laws of the geographical distribution of animals and plants and of their gradual development during the geological epochs, could only outline the broad features of the theory. Evidently its basis must be sought in the study of the process by which one species is produced from another. Which is the nature and which are the causes of this process? Which are the elementary changes which, by numerous repetitions and combinations, have produced the main evolutionary lines of the animal and vegetable kingdom?

In order to answer these questions, Darwin studied the experience of the breeders. The improvement of domestic animals was well known at his time; the cultivated races of flowers and vegetables, of cereals and sugar-beets, clearly and widely surpassed the same species in nature.

The method of breeders is based on the principles laid down about the middle of the last century (1840) by P. P. A. Lévêque de Vilmorin, the father of the celebrated founder of the culture of sugar-beets. He had observed the high degree of variability of cultivated plants and discovered that by means of a choice of the best samples and by their isolation highly improved varieties may be produced. His son has applied this principle to the sugar-beets, one of the most variable of all cultivated forms, and succeeded in increasing the amount of sugar from 7 to 14 per cent. This improvement soon became the basis of a large sugar industry in many countries of Europe. From that time isolation and selection have become the watchwords of a big new industry, which soon produced the most unexpected results in almost all parts of agricultural practice.

Darwin transplanted this principle of practice into pure science. He studied the variability of species in the wild condition and found it as widely spread and as rich in its features as in cultivated forms. He saw that very many species are distributed in nature in such a way as to constitute numbers of isolated colonies, sufficiently distant from one another to exclude the possibility of intercrossing. He discovered the great factor which replaces artificial selection in nature and called it by the name of natural selection. It is the unceasing struggle for existence and the victory of the most endowed individuals. In nature, every plant produces more seeds than can develop into new plants, owing to lack of space. Only those which are most fit for the surrounding conditions will survive, while the remainder are condemned to disappear. In this manner the struggle for life leads to a selection, which will be repeated in every generation, and a whole colony may gradually change by this means until at the end the characters are sufficiently different from the original ones to constitute a new variety or even an elementary species.

Natural selection in the struggle for life has now become the main principle of organic evolution. Since species obey in the wild condition the same laws as under cultivation, the principles of their improvement must be the same everywhere.

Darwin applied this principle to geological evolution also. Lyell had shown that the laws of nature have always been the same from the very beginning. Therefore natural selection must have been active from the first time of the existence of life on earth and have produced the main lines of differentiation, as well as the first traces of all those groups which are now recognized as families and genera. It is my conviction that the success of Darwin in this line of ideas has been as complete as possible. He succeeded in convincing his contemporaries of the essential analogy between artificial and natural selection.

But, on the other hand, it must be conceded that the practice of breeders was not as simple as it seemed to be. No thorough study of the phenomena of variability had been made, and it was simply assumed that the diversity of forms within the cultivated races was due to one cause only. This was indicated by the well-known expression that no two individuals of a race are exactly alike. All specimens differ from one another in their industrial qualities as well as in their botanical characters. These qualities and characters are inheritable and the offspring of a selected individual will vary, according to Vilmorin, around an average lying between the type of the original species and that of the chosen individual. By this means the range of variability will be extended in the desired direction, and this may be repeated during a number of years, until the industrial value of the new race clearly surpasses that of the old one.

Evidently, it was said, natural selection must work in the same way. But the question remains whether this will really lead to new species, or only to local and temporary adaptations.

The answer to this question has been given by the newest discoveries of agricultural practice itself. Hjalmar Nilsson, the director of the celebrated experimental station of Svalöf in Sweden, discovered that variability among cultivated plants is not a single phenomenon, but contains at least two widely contrasted features.

He found that, apart from fluctuating variability, every cultivated species is a mixture of elementary types. A field of a cereal is only apparently uniform, and a closer investigation soon reveals numerous differences in the height of the stems, in the time of flowering, in the size and almost all other qualities of the ears, in resistance to diseases, and especially in the industrial value of the grains. Moreover, he found that all these qualities are strictly inheritable. Nilsson took the grains of a single ear and found that all the individuals issuing from them are strictly alike and carefully repeat the characters of their mother. From such a chosen ear one may derive by repeated sowings grain enough to sow a whole field, and this will show an almost complete and very striking uniformity. Therefore our ordinary species and varieties of cultivated plants are in reality mixtures of a smaller or larger number of different races, which grow together, but are, as a matter of fact, independent of one another. These races themselves are almost invariable, but their mixture in the field produces upon us the impression of a great variability.

What is the significance of this discovery for the explanation of artificial selection? Evidently this will tend to isolate the better races of the mixture and to exclude those of average or low value. Two methods may be followed: Either the breeder collects a handful of ears chosen with the utmost care from all parts of his field and secures a lot of grains large enough to sow a parcel of a moderate extent, or he limits his choice to one ear only, which will take him one year more to obtain the necessary quantity of grains. The first method is the one which is still commonly followed, the second was introduced some twenty years ago by Nilsson.

The real nature of the first method may be explained by means of the careful studies of Rimpau, who applied it for the improvement of his rye. The group of ears of the first choice will evidently be itself a mixture, although of a lesser number of types. In choosing year after year a handful of the best ears Rimpau must gradually have purified this mixture, until after twenty years he succeeded completely in isolating the very best one of them. From this time his race must have been pure and constant, no further selection being possible. Using the method of Nilsson, the same result may be reached by a single choice, and therefore in one year. The new race is produced by a jump and not by the slow and gradual improvement, by small and almost invisible steps, which was assumed by Rimpau and Darwin.

From these discoveries the question arises, whether natural selection also proceeds by jumps and leaps, and not, as was commonly assumed, by imperceptible steps? The answer may be deduced from the observations of Jordan and others on the existence of elementary species in nature. Almost every wild species consists of some of them, and in special cases their number increases so as to embrace dozens or even hundreds of sharply distinguished types. Sometimes these are found in widely distant stations; at other times, however, they are growing in mixtures. Natural selection will, of course, under changed conditions, simply multiply one or two of the types to the exclusion of the others. As a whole, the species will make progress in the desired direction, but in reality there will be no change of forms.

From all these and many other considerations it follows that the basis, which the practice of artificial selection seemed to afford to the theory of natural selection, is a fallacious one, and that the idea of evolution by means of slow and almost imperceptible steps must therefore be abandoned. But if this is conceded, how are species really produced in nature?

The theory of mutations answers that species are produced by means of jumps and leaps, exactly in the same way as varieties in horticulture. Varieties are only beginning species, says Darwin, and the same laws must govern the origin of both of them. Now, in horticulture, it is well known that varieties usually arise at once. In a field of a species with blue or red flowers some day an individual with white flowers is seen. Ordinarily it is only one, and it is not surrounded by transitions or by flowers of intermediate colors. Sometimes there may be two or three, but then their flowers are of the same degree of whiteness. One seed of the species has been transformed into a variety, and this is its whole origin. A single season suffices to produce the effect, no slow and gradual improvement being required. Moreover, the seeds of the first individual, if fertilized and saved separately, will reproduce the variety wholly pure. The same rule prevails for large groups of other cases; everywhere varieties arise by jumps, requiring only one year for their arrival.

The same rule also holds good in nature. But in order to show this, direct experiments are required. For this object I have cultivated a large number of wild species in my experiment garden, trying to see them produce varieties, and to be enabled thereby to study the laws of this process. Let me adduce two instances, the origin of the peloriated toadflax, and that of the double variety of the corn marigold. These varieties appeared in my cultures all of a sudden, after a number of years, the one in about half a dozen of individuals in successive generations, the other in a single instance. The ordinary toadflax has only one spur on its flowers and remained so in hundreds of individuals until a single specimen bore five spurs on every one of its flowers. The corn marigold had normal flower heads until 1899, when one individual produced some slight signs of duplication. Next year all its descendants bore double flowers and the race showed itself constant from the very beginning.

Thus the production of varieties by leaps and jumps may be considered as a well-proved fact in horticulture, and in a state of nature. It is a firm basis for a new theory, and is readily understood, as we have only to transport the principle from the varieties to the origin of elementary species. Recognized for species, the theory will obviously be true for genera and families also, and explain the evolution of all organic beings in all the different lines of the genealogical tree.

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[*] From an address delivered at the University of Brussels, January 17th, 1914.

[1] "The Mutation Myth" is the title of a recent article in *Science*, N. S., vol. xxxix. No. 1005, April 3rd, 1914, p. 488. Its author, Edward C. Jeffrey, starts from the conception that the mutation theory has been derived from my experiments with *Œnothera Lamarckiana* and allied species. This opinion is indeed, even yet, not unfrequently held by those who have not read my books. It is obviously erroneous and therefore may well be called a myth. Logically and historically the desirability of those experiments has been derived from the theory, as will be seen in the text. Jeffrey bases his arguments upon the well-known researches of Geerts concerning the partial sterility of many of the members of the natural family of the *Onagraceæ*. Geerts found that in almost all the genera of this family, including all their species as far as investigated, the ovules are for one half in a rudimentary condition, which excludes the possibility of their being fertilized, while about one half of the pollen grains is sterile. This double character has therefore persisted during the pedigree-evolution of almost this whole family. In contradiction with Geerts, Jeffrey considers it to be an indication of a hybrid condition. If this were true, almost the whole natural family of the *Onagraceæ* would have evolved in a hybrid condition and *Œnothera Lamarckiana* would follow the rule. It remains doubtful, however, how this hypothesis could explain the high degree of mutability of *Œ. Lamarckiana*, since the majority of the supposed hybrid species do not show signs of such a condition.

The idea of the origin of species by leaps and jumps has the great advantage of answering in an unexpected and decisive way the numerous and, in part, very grave objections which have been brought forward against the theory of Darwin. To my mind, this is one of the best arguments in its favor. It releases the theory of evolution from the serious difficulties which its adversaries have never ceased to urge against it. Therefore it seems useful to give a brief survey of them now.

The oldest and most serious objection is based on the obvious uselessness of new characters during the first stages of their evolution, if this is supposed to be invisibly slow. Imperceptible odors cannot guide insects in their visits to flowers and assure to these a sufficient advantage in the struggle for life. Adaptations for the capturing of insects by plants would be of no value in a primary and imperfect condition, and therefore cannot be evolved by the action of natural selection. Imperfect instincts would be rather obnoxious, according to Wasmann, and thus would be liable to be destroyed instead of increased by this action. So it is in many other cases. Beginning characters would always be too insignificant to be of any value in the struggle for life. Evidently the principle of leaps and jumps at once relieves us of the necessity of this hypothesis. It does not admit a gradual appearance of characters, but assumes these to appear at once in the full display of their development, and without the aid of natural selection.

The same holds good for useless characters. The theory of Darwin cannot explain them. According to him, every quality is developed exactly through its utility, and useless properties should be eliminated from the very beginning by the struggle for life. But it is now generally recognized that many beautiful differentiations are in reality no adaptations at all, and that their usefulness is at least very doubtful. This, for instance, is the case of heterostyly and of the likeness of the flowers of some orchids to insects. The theory of mutations has no difficulty with useless, and even with slightly prejudicial characters. Arising by a sudden jump, they may keep their place, provided only that they are not in such a degree hurtful as to prevent a normal development of the individuals.

A third objection has been derived from the studies of the celebrated anthropologist Quetelet, who discovered the general law of fluctuating variability. He introduced the principle of studying every quality for itself and of comparing the different degrees of its development in a large number of individuals. He found by this means that characters simply follow the laws of probability. They vary around an average condition in two directions, of increase and decrease, but precisely thereby this variability excludes the production of a new character. Darwin tried to derive the one from the other, while the theory of mutations recognizes the almost diametrically opposed nature of the two phenomena.

A last objection has been brought forward by the study of the age of the earth. Physicists as well as astronomers have refused to accept the theory of slow evolution, as the time required by Darwin in connection with his ideas seemed by far too long. A man's life would not suffice to see the changes, which, after him, would be necessary to produce a single step in the line of evolution. The differentiation of a flower or of a seed would require millions of years if it went on so slowly, and the development of the whole organism of a plant, and still more so that of the higher animals, would obviously require a vastly larger amount of time. Darwin has calculated the necessary time for the evolution of the whole animal and plant kingdom on the assumption of slow and almost imperceptible changes, and estimated it to be at least equal to some thousands of millions of years.

But our globe cannot be as old as that. There is quite a large number of arguments which allow us to estimate the age of the earth with a sufficient degree of accuracy, and they all point, unanimously, to a period of only some twenty or forty millions of years. This number is evidently far too small for the explanation given by Darwin, and in consequence thereof it has always been considered as one of the most decisive arguments against the theory of slow and gradual evolution.

In order to estimate the age of the earth different phenomena may be used. First the separation of the moon, secondly the solidification of the earth's crust, then the condensation of the aqueous vapor and the formation of oceans. The quantity of salt dissolved in these oceans and the thickness of the geological layers, especially those of a calcareous nature, afford further arguments.

According to George Darwin, the moon was separated from our globe about fifty-six millions of years ago. The age of the solid crust has been calculated by Lord Kelvin from the increase of the temperature in deep mines. In some regions the temperature is seen to increase about one degree for every fifty meters; in others, however, one degree for a hundred meters. On the average the considerations of Lord Kelvin gave an age of twenty to forty millions of years for the solid crust of the earth.

The quantity of salt obviously increases in the oceans on account of the salt added by the rivers and of the evaporation of the water. The total quantity of this salt has been calculated and the quantities of the yearly supply of water are known for all the larger streams, as well as their percentage of salt. From these data we may calculate the annual increase of salt in the oceans and find how many years would be required for our present rivers to accumulate all the salt now found in the seas. According to Joly, about ninety millions of years would be necessary. But obviously the rivers must exhaust the grounds which they drain, and formerly these must therefore have been much richer in salts. This consideration must lead us to diminish the number of years required in a very sensible manner.

The age of the geological strata has been deduced from their thickness and the velocity of the process of sedimentation. Sollas estimates the total thickness at about eighty kilometers and the average rate of deposition of the layers at 30 centimeters per century. From these numbers we may find an age of twenty-six millions of years for the collective deposition of all the geological layers. Calcareous rocks have been built by organisms and mainly by corals and molluscs. These have made use of the lime added to the sea by the rivers. Dubois has calculated on the one hand the whole thickness of these rocks, and on the other the yearly supply of lime from the rivers. He concludes that thirty-six to forty-five millions of years would be required to produce the whole of this system.

All these data have been subjected to a criticism by Sollas and compared with one another. Obviously the highest estimates are only limits, and in considering this Sollas arrives at the general average of about twenty to forty millions of years. He points out that the epochs which have served as starting points are not very far distant from one another, considered in a geological way, and that therefore they may be taken together to delineate the duration of organic life on this earth.

As we have seen, this duration is by far too short to allow the slow and gradual development of life supposed by Darwin. It necessitates a very substantial abbreviation of this process, and thus affords one of the best supports of the theory of mutations.

Thus we see that this theory is based on almost all the branches of natural science. All of them join in the assertion that the hypothesis of slow and almost invisible changes is too improbable to be accepted, and is even in open contradiction to some of the best results of other sciences. The theory of an evolution by leaps and jumps evades all these objections, and thereby releases the theory of Darwin from its separate position.

But it is doing more than this. By rejecting the hypothesis of invisible changes it leads us to search for the visible alterations, which it assumes to be the leaps and jumps by which animal and vegetable species are being produced. If the transformation of one species into another be a visible process it must evidently be sought for and be brought to light in order to study its laws, and to derive from this study an experimental proof for the theory of evolution.

However, it is hardly probable that these jumps are numerous in nature as it now surrounds us. On the contrary, they must rather be rare, since nobody had seen them until now in the field. Therefore I have sought for a plant which would produce more of such mutations than other plants. I have studied over a hundred species, investigating their progeny, and among them one has answered my hopes. This is the evening primrose of Lamarck, which chances to bear the name of the founder of the theory of evolution which it is prepared to support. It is a species which grew wild in the territory of the United States, where it has been collected by the well-known traveler and botanist Michaux, and whence Lamarck derived the authentic specimen for his description. Since that time it has spread in Europe and is now found especially in England, Belgium, and Holland in a number of localities, some of which consist of many thousands of individuals. In more than one of these localities it has been observed to produce mutations, especially in a field near Hilversum in Holland, whence I have obtained the individuals and seeds which have served as the starting points of my cultures.

In these cultures the species is seen to be very pure and uniform in the large majority of its offspring, but to produce on an average one or two aberrant forms in every hundred of its seedlings. The differences are easily seen even in young plants, and are mostly large enough to constitute new races. The more common ones of these races are produced repeatedly, from the seed from the wild plants as well as in the pure lines of my cultures. It is obviously a constant and inheritable condition which is the cause of these numerous and repeated jumps.

These jumps at once constitute constant and ordinarily uniform races, which differ from the original type either by regressive characters or in a progressive way. By means of isolation and artificial fecundation these races are easily kept pure during their succeeding generations.

I shall not insist here upon their special characters. The most frequent form is that of the dwarfs, *Œnothera nanella*, and the rarest is the giant, or *O. gigas*, which has a double number of chromosomes in its nuclei (28 instead of 14), and by this mark and its behavior in crossing proves to be a progressive mutation. Other new types which are produced yearly are *O. rubrinervis*, *O. Oblonga*, and *O. albida*. *O lata* is a female form, producing only sterile pollen in its anthers, and *O. scintillans* is in a splitting condition, returning every year in a greater or less number of individuals to the original type from which it started. Besides these there are a large number of mutations of minor importance, many of which have not even been described up to the present time.

Thus we see that the experiments provide us with a direct proof for the theory of evolution. They constitute an essential support of the views of Darwin, and moreover they relieve them of the many objections we have quoted, and bring them into harmony with the results of the other natural sciences.

But, besides this, they show us the way into a vast new domain of investigation and afford the material for a study of the internal and external causes which determine the production of new species, at least in those cases in which, as in the primroses, mutations are relatively abundant. From these we may confidently hope to come some day to the study of those rarer mutations on which the differentiation of the main lines of organic evolution seems to have depended.

An Idiot's New Brain

At the last meeting of the Paris Academy, Dr. Serge Voronoff read a remarkable paper on the operation performed by him at the Clinique Sainte Marguerite, near Nice, in the course of which he gave to the world the first news of a fresh scientific miracle; in fact, a sort of supermiracle, as it consists of nothing less than inoculating a cretinous youth, alias an idiot, with something taken from a monkey, and—*mirabile dictu!*—improving the intelligence of the boy.

The miracle is stupendous in every way as to the result announced, but how a mere layman is to explain it is the difficulty. I confess that I do not understand myself the processes of the operation, and I must leave it to scientific experts to correct any involuntary mistakes which a layman may make. The boy was 11 years of age. He had been normal up to the age of 8, when he had an attack of scarlatina, following which all the characteristic accidents of cretinism were developed. His skin became yellow and pink and scaly and dry. His hair became scarce and brittle, his eyelids swollen, his nose flattened, his cheeks flabby, his whole face bloated. The eye was dull, and the expression of his face idiotic.

Six months ago Dr. Voronoff grafted the right lobe of the thyroid gland of a baboon on the lower part of the boy's cerebral organ. The effect was both immediate and progressive. Day by day the child's mental and physical condition improved. His face lost its sickly color and its flattened appearance. The child's growth, which had been checked, began again, and has since continued normally. His mental improvement was still more remarkable. The boy, who before had been dull and obtuse, and had taken no interest in his surroundings, in his lessons, or in his companions, surprised his schoolmaster by becoming alert, bright, and finally even mischievous. He is now keen alike in the school and in the playground. Dr. Voronoff explains that the cretinous disposition is brought about by the absence of the secretions produced by the thyroid gland. The difference between an intelligent man and an imbecile, he says, does not depend altogether on the development of the brain, which may be the same in both, but on the secretions of this gland, which have a particular effect on the intellectual activity of the cerebral matter. Give an imbecile a thyroid gland in good working order, and he will display the keen intelligence which he actually possessed, but which remained inert because his brain did not receive the necessary stimulus.—*The Daily Telegraph.*

The Ancon Meteorological Observatory, in the Canal Zone, is about to be installed in the new administration building at that place. An 80-foot steel tower is being erected to support the anemometer, wind-vane and sunshine-recorder. A seismograph will be installed in the basement of the administration building.

Producer Gas for Industrial Purposes*

Economy and Convenience Where Both Power and Heat Are Required

By Thomas Wilson

WITHIN the last few years the use of gas for heating purposes in many industries has greatly increased. Cleanliness and convenience and the ease with which it can be controlled so that the temperature can be closely regulated have been the deciding factors. Natural and city gas have been used to good advantage, but for low-temperature work up to 2,000 deg. Fahr. anthracite producer gas has given equal satisfaction at a much lower cost. The cost item has induced manufacturers to install gas producers using inferior grades of anthracite to supply gas, not only for heating purposes, but for power.

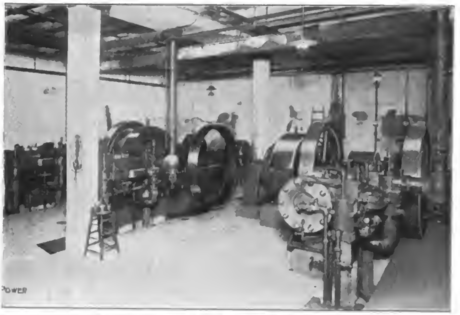

Fig. 1.—Gas-engine plant at Barnhart Brothers & Spindler.

A plant involving this double service has been installed in the new factory of Barnhart Brothers & Spindler, Chicago, makers of type and printers' supplies. The gas is used for melting the metal in type-casting machines, for hardening furnaces, machine torches, brazing torches, for lead and slug casting, in annealers, copper- and nickel-plating baths, etc. About 70 per cent is required for these purposes and the balance by the engine units generating current for power and lighting.

There are 70 type-casting machines, each equipped with individual motors. All chases are electrically welded, for which fully 75 horse-power is required. A machine shop in which the factory machines are made and repaired takes considerable power; besides, there are electrically driven pumps and fans, and an elevator and conveying machinery to move the product in the course of manufacture. When the plant is running to full capacity, with the chase department in operation, the load will average close to 150 kilowatts, and when chases are not being welded it will drop off one third. Consequently, two units have been installed, one a 125 horse-power, 17¼ by 16-inch, four-stroke-cycle tandem gas engine directly connected to a 75-kilowatt direct-current generator, and the other a twin engine of the same type and size of cylinders driving a 150-kilowatt generator; the speed in each case is 250 revolutions per minute. These machines are operated 10 hours a day, and it is the plan to use them alternately, depending on the welding periods. The plant also has a breakdown service; but so far it has been called on only for night lighting, for the fire pumps and for starting the blower, run in connection with the two producers of 350 horse-power each.

As the plant has been running only a short time no satisfactory records are available, but it may be said that the gas, which averages about 145 and has reached 151 British thermal units per cubic foot, has given excellent satisfaction both for heating and power purposes. About 95 pounds of buckwheat No. 1 in the producer is equivalent to 1,000 cubic feet of natural gas containing 800 British thermal units per cubic foot, and 75 pounds is equivalent to the same quantity of city gas containing 550 to 600 British thermal units. At $5 per ton, which is a high charge for such coal in quantities, the fuel cost would be 24 and 19 cents, respectively. To this must be added the labor item and the interest and depreciation on the producer installation; even then the total cost does not exceed much more than one third the usual charge for city gas. In a preliminary estimate, the equivalent of 1,000 cubic feet of city gas was figured to cost 31.3 cents, including a charge for water and interest and depreciation amounting to 16 per cent. For the engines the guarantee was 1¼ pound of buckwheat No. 1 per brake horse-power-hour at full load, which at $5 per ton gives a fuel charge of 0.28 cent. This amount will generate about 79 cubic feet of producer gas, and with a heat content of 145 British thermal units will supply 11,455 British thermal units per boiler horse-power-hour.

THE PRODUCER PLANT.

In this department each of the two Flinn & Dreffein units is rated at 350 horse-power and consists of a producer and an economizer; a scrubber serves the two generators. The producers, of the water-sealed type, have a heavy steel shell 8 feet in diameter by 12 feet high, firebrick lined, and rest on legs in a concrete pan. The fuel is supported on a layer of ashes on the bottom of the pan. Between the bottoms of the shell and the pan there is a clearance of 12 inches, and as the pan diameter is greater than that of the shell, there is room for removing the ashes, which are placed in 400-pound cans, hoisted to the street level and carted away.

Coal from a 100-ton bunker below the street level is delivered by gravity through a chute into the bucket of a 1-ton electric monorail hoist, which for feeding can be moved directly over the hopper of each producer. At their rated load the two require 750 pounds of coal per hour, although they are now running at only two thirds capacity. The producers are not charged heavily, but are fed uniformly with 150-pound charges at 35-minute intervals. The hoist bucket easily holds ten charges, and is usually filled four times each day.

The coal enters the producer through a double-seal hopper, a counter-weighted bell at the bottom of the hopper preventing the admission of air while the coal is being fed. The sliding plate at the top is closed while the bell is lowered, so that the coal may run down over it and be evenly distributed over the fuel bed. The hopper rests on a water-cooled top having poke holes for attending to the fuel bed.

A feature of the producer is the annular tuyere of doghouse cross-section, which uniformly distributes the air and steam to the fuel bed. This construction facilitates the ash removal, as the ashes can drop around or within the annulus and easily reach the concrete pan at the bottom.

An important part of the plant is the economizer, which in the present installation is 9 feet high and 42 inches diameter, and consists of two concentric steel shells forming two chambers. The gas from the generator passes through the inner one and gives up part of its heat to the air flowing in the opposite direction through the outer chamber to the fuel bed. Ordinarily the gas leaves the producer at 1,200 deg. Fahr., and if it passed directly to the scrubber it would carry about 12 per cent of the heat in the coal. By raising the temperature of the air to 500 degrees in the economizer, two thirds of this heat is reclaimed.

In the pipe connection between the top of the outer chamber and the tuyere of the producer, a steam blower is inserted to saturate the air and equalize the pressure in the top of the producer; otherwise, there would be a slight depression caused by the suction of the engines and of the blower supplying the shop equipment. Atmospheric pressure is thus maintained so that there is no tendency for air to be drawn in or gas to be blown out through the poke-holes when attending the fuel bed.

With the air at this high temperature, combustion is facilitated and the steam is carried to the fuel bed without condensation; it is also claimed that a richer gas is thereby obtained. The steam is supplied by a small vertical fire-tube boiler rated at 15 horse-power and having a pressure of 50 to 80 pounds, depending on the load the producers are carrying. The quantity of steam is controlled by a gasometer connected by block-and-tackle to a weighted lever attached to the stem of the balanced steam valve. The gasometer connects with the top of the producer. As the load increases, the gas pressure tends to drop, so that the gasometer lowers slightly, and, through the connecting links, increases the opening of the steam valve. A drop in load produces the reverse results.

From the economizer to the wet scrubber the gas passes through a three-way water-sealed valve from the top of which the purge pipe leads to the roof. Water-sealing the valve eliminates any possible trouble from tar and soot sticking to a dry seat and makes the tightness of the valve more certain. The scrubber serving the two units is 6 feet 6 inches in diameter by 22 feet high, and contains a coke column supported on trays, water sprinklers above, and at the top a layer of excelsior to remove the moisture.

From the scrubber the gas is drawn directly to the engines by the suction of the pistons. As for industrial purposes, it is necessary to supply the gas at a definite and uniform pressure; there is an exhauster belt driven

Fig. 2.—Charging floor of producers.

Fig. 3.—Bottom of generators and steam boilers.

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* Reproduced from *Power*.

by a 15 horse-power motor. Instead of using a gas holder, a pipe connection is made between the delivery and suction sides of the exhauster. In this line is a back-pressure valve weighted for the desired pressure; when this exceeds the predetermined value, the valve opens and returns part of the gas to the suction side of the exhauster. The latter is run at constant speed so that the maximum output will be available. To the valve spindle is attached a diaphragm subject to the pressure in the gas main, and opposing this are weights on the upper side of the diaphragm. The construction is such that the diaphragm casing may be rotated at will, pulling with it the valve disk and thus keeping it free from soot or deposit by the grinding action on the seat.

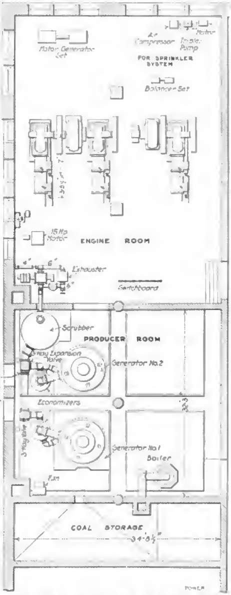


Fig. 4.—Plan view of engine and producer rooms.

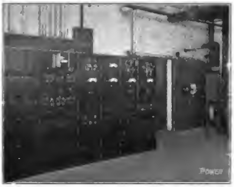


Fig. 5.—Switchboard, static washer, and exhauster.

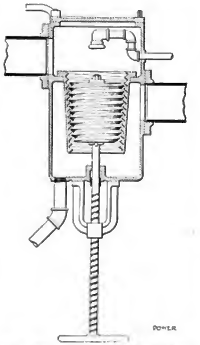


Fig. 6.—Sectional view through static washer.

For the engines, the gas is clean enough as it comes from the wet scrubber, but for small burner work it must also be passed through a static washer operating on the impact principle. The washer, Fig. 6, consists of a chamber having two compartments, the upper one giving space for gas admission and a spray of water. Hanging from the dividing wall is a threaded cylinder with a piston having threads of the same pitch, but not in contact with those of the cylinder wall. Both are so tapered that as the piston is moved downward the flow area is lessened and the velocity of the gas is increased, or *vice versa.* The stem attached to the piston has threads of the same pitch also, so that in moving the piston up or down there is no variation in the "mesh."

In passing through this zigzag course, the remaining soot particles in the gas are deposited on the metal surfaces and washed down through the drain at the bottom of the lower compartment. The purified gas passes on to the burners.

ENGINE ROOM.

The engines are of the tandem type directly connected to 110-, 220-volt, three-wire generators, with a balancer set. Rites inertia governors acting through balanced cut-off valves control the speed, and under the severe conditions imposed by the welding department they have maintained close regulation.

The plant is distinctive in design in that any part of either engine, with the exception of the crankshafts and flywheels, is interchangeable, and either half of the twin engine can be run independently of the other. In this way, one tandem unit can be out of service and the other two will be available to furnish the maximum load of 150 kilowatts.

A 10-inch pipe from the scrubber, with 6-inch taps to each tandem unit, supplies the gas to the engines. From the twin engine, two 6-inch exhaust pipes discharge to a 12-inch muffler; this reduces to 8 inches as it leads to the roof. The single tandem engine has a 6-inch exhaust, a 10-inch muffler and a 6-inch riser.

Air for starting is stored in two 30-cubic foot tanks at 200 pounds pressure during the day by a motor-driven compressor. From a 5,000-gallon tank on the roof, cooling water flows through the engine jackets and then to the suction of a 2-inch motor-driven centrifugal pump which returns it to the tank through a cooling tower above the tank. In case of accident to the pump, city water will be used temporarily.

Other equipment includes a pump and air-compressor unit for the sprinkler system, a motor-generator set to supply current of the proper voltage for welding, two bilge pumps to raise the sewage to the necessary level, and a triplex pump to circulate water through the type-casting machines.

For heating the building, two water-tube boilers, each able to serve 10,000 square feet of radiation, supply steam at a 5-pound pressure to a vacuum system having 16,000 square feet of radiation. A steam plant was first considered, but because of the low efficiency in summer, of insufficient exhaust steam to supply the heating for at least part of the winter, and because gas was needed in the shop, the present plant appeared to be the best; considering its brief period of operation, nothing has happened to gainsay this decision. The gas for both services has given satisfaction, and, from the meager data available, the cost has been exceptionally low.

Amputations Less Frequent in War

INTERESTING figures of the cost of medical service in war and the percentages of death from wounds in modern warfare are given in an editorial in the *New York Medical Journal.* The *Journal* quotes Prof. Charles Richet of the University of Paris as authority for the assertion that ambulance service alone for 500,000 wounded or ill costs $1 a day for each, or $500,000.

"This is a startling sum," says the editorial, "but apparently it does not take into consideration the cost of feeding the doctors, nurses, and either chauffeurs, or drivers of horses connected with the ambulance service, while there is no estimate of the first cost of the elaborate paraphernalia, drugs, apparatus, instruments, etc., required."

Roughly speaking, the editorial asserts, battle casualties in recent wars have varied from 10 per cent to 20 per cent of the number of soldiers engaged. The ratio of killed and wounded has been about one to four. Of the casualties, from 65 to 80 per cent were caused by rifle fire and from 20 to 30 per cent by artillery fire, chiefly shrapnel. Bayonet and saber wounds have been of comparatively infrequent occurrence, and little mention is made of them in reports. In the civil war in this country 90 per cent of the total wounds recorded were caused by small arms, while the injuries from artillery amounted to only 9.87 per cent of the total wounds.

"The increase in range, the rapidity and accuracy of fire developed in modern military firearms, supplemented by the relative increase in the strength of field artillery, will have an important bearing upon the character of the wounds and the number of the casualties," say the *Journal* in commenting on the present war. "Experience in recent wars has demonstrated the character of the injuries produced by modern firearms. The European powers have all adopted rifles with similar ballistic properties. The bullet is jacketed, of small caliber, varying from 6.5 millimeters to 8 millimeters, and weighs from 150 to 200 grains. It is either ogival or pointed in shape and has an initial velocity of from 2,000 to 2,700 feet a second.

"The pointed or 'spitz ball' has been adopted by England, Germany, Turkey, and the United States. The wounds inflicted are, therefore, entirely different from those inflicted by the rifle in use several decades ago. This weapon had a low velocity and carried a soft leaden bullet of large caliber.

"Experiences in the Russo-Japanese and Balkan wars have demonstrated that at the greater ranges perforations of the abdomen, chest, and skull may take place with astonishingly slight effects. This statement must be modified so far as the pointed bullet is concerned, since this bullet has its center of gravity near its base, and is usually 'set up' on meeting with slight resistance, thus forcing its way through the tissues in its length instead of in its diameter.

"Fatal primary hemorrhage occurs much more frequently than in earlier wars, because the small-caliber jacketed bullet is more likely to sever vessels, while the large-caliber bullet, moving with less velocity, affords time for the blood vessel to be pushed aside from its course.

"It has been estimated that 85 per cent of deaths on the modern battlefield are due to hemorrhage. Secondary hemorrhage, which in former wars was of such common occurrence, nowadays rarely occurs, while traumatic aneurism is much more frequent.

"Amputations are much less frequently necessary, and then only where there is extensive destruction of limb, as in wounds by large shell fragments, or injuries to blood vessels completely arresting circulation. Wounds inflicted by the modern rifle bullet, if properly protected against infection, never require amputation unless the circulation is arrested. Machine guns use the rifle ammunition, and the wounds inflicted by them are identical in character with those inflicted by other small arms.

"The wounds inflicted by shrapnel differ from those caused by the rifle bullet in that they are accompanied by a greater contusion and involve a greater amount of tissue, shrapnel bullets being of greater size and having a much lower velocity. Shrapnel wounds are frequently multiple, and almost invariably suppurate, since they are very apt to carry foreign material from the clothing into the wound."

The Flying Machine from an Engineering Standpoint—IV*

A Review of Recent Progress

By Frederick William Lanchester, M. Inst., C.E.

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2016, Page 127, August 22, 1914

7. *Motive Power Installation.*—We are now faced with the consideration of the motive power installation. At the present time the internal-combustion engine—more definitely the gasoline motor—holds the field. No other prime mover is able to compete, either on the score of weight per horse-power or fuel-weight economy; there is nothing in sight likely to oust the internal-combustion motor from its supreme position.

The relative importance of lightness and economy of fuel is determined by the class of service for which the motor is required. In Fig. 27 curves are given of weight/horse-power for various motors; ordinates represent weight of motor plus fuel, abscissæ the duration of the run at full load. It can be seen at a glance from this diagram that for brief periods the weight per horse-power of the engine is the all-important factor, whereas for long runs this becomes relatively less important, the weight of gasoline and lubricating oil becoming the main item. On referring to Fig. 27, it will be noted, taking the extremes, that the Gnôme engine starts with a very considerable advantage over the motor-car engine given for comparison, but after a run of 17 hours at full load, the motor-car engine (represented for the purpose of illustration by the Daimler) by its greater economy has taken the lead. This diagram was prepared by me some three or four years ago (see Report of the Advisory Committee for Aeronautics for 1909-10). Many of the aeronautical motors of the present day combine with a weight/horse-power factor of about 4, a degree of economy that compares well with the best automobile practice.

Fig. 28.

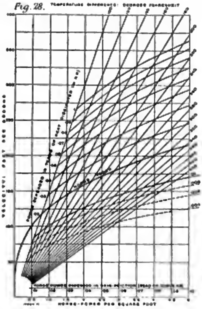
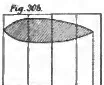


Fig. 30b.



Out of the great multiplicity of types of aeronautical engine now on the market there are two types, namely, the rotating engine on the one hand and the light weight multi-cylinder V type on the other, which I consider likely to survive. The rotating type of engine gives the possibility of very complete balance with simplicity of working parts, and so provides the aeronautical constructor with an engine especially serviceable where small machines are concerned, and simplicity and upkeep[31] are of importance. The rotating engine is, at the present day, reasonably economical in gasoline, but is grossly extravagant in lubricating oil, and consequently is at a disadvantage for long-distance work; it will, however, probably hold its own for some time to come in machines for short-distance flying. The rotating engine, also, suffers from some disadvantages on the score of exhaust silencing. The multi-cylinder V type, though ordinarily not so light, power for power, as the rotating engine, has many advantages, especially for high power and where long distances have to be negotiated.

Fig. 27

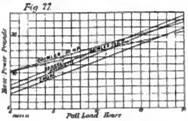


Fig. 29

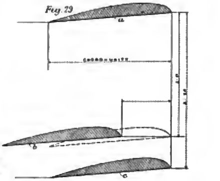
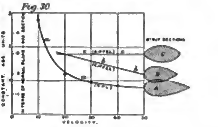


Fig. 30



It is customary in the rotating engine to employ direct air-cooling; it is, in fact, difficult to arrange such an engine with water-cooling. The horse-power absorbed in the Gnôme engine incidental to air-cooling is very great; in the original so-called 50 horse-power Gnôme (which actually gives very little over 40 horse-power in flight), the power consumed in wind resistance, even on the test stand, amounts to something nearly 6 horse-power, and it may be materially greater under flying conditions.

In engines of the V type, water-cooling is in greater favor; the Renault special aeronautical motor is an exception, being cooled by air-blast generated by a centrifugal fan. The weight of the water-cooling system when fitted amounts at the best to 0.6 pound per horse-power (with water nearly 1 pound per horse-power), and thus constitutes a serious addition to the weight of the installation. Here, again, the class of service becomes important. It is evident that for short-distance flying, where engine-weight is of paramount importance, it may be better to employ direct air-cooling; when, however, a long-distance service is required, it may arise that the weight of the water-cooling system is justified by the saving in horse-power and better fuel consumption.

According to a recent investigation by me[32] the minimum horse-power expended in cooling, that is to say, the horse-power necessarily expended in cooling, is a function of the area and temperature difference of the surface exposed, and there is some difficulty in providing an air-cooled engine cylinder with sufficient gill surface to keep the horse-power loss as low as desirable; when on the other hand water is used as a heat carrier, the rigid limitation as to available surface no longer applies, there is some disadvantage, however, as to temperature difference. In Fig. 28 a diagram is given showing the essential relations between horse-power, equivalent of heat dissipated per square foot surface (abscissæ), tangential velocity of air (ordinates), temperature difference, and power absorbed in skin friction. It will be understood the graphs represent the minimum horse-power absorbed, based on the assumption that the air in traversing the surface along a stream-line path, and that there is no additional loss of power in eddy-making (other than that incidental to skin friction); the honeycomb type of radiator most nearly complies with this condition.

We may now proceed to consider the interrelation and compatibility of engine and propeller. It has already been pointed out that in order to get the full output from a given engine (as is also well known to be the case in marine propulsion), a propeller pitch has often to be selected far from that proper to highest efficiency. The difficulty has (as in the early Wright machine) been met by adopting a reduction gear; alternatively (as also in the Wright machine) a multiplicity of propellers may be employed. It is evident, for example, that, if four propellers be used in place of one propeller, the individual diameter may be halved, and consequently for a given pitch (and therefore revolution speed) the pitch diameter ratio doubled. The original Wright machine furnished a good example of a case in which the propeller pitch diameter ratio was made approximately that of best efficiency, and this result was obtained, in spite of the low velocity of the Wright machine, by a combination of both methods: that is to say, two propellers were used instead of one, and these propellers were geared down from the engine in the relation 10 to 33.

The incompatibility at present existing between the engine speed and the propeller pitch becomes less as the flight velocity is increased, so that, in the case of an ordinary machine of about 1,400 pounds total weight, the propeller speed (for best efficiency) for a single-screw machine becomes appropriate to the normal engine speed at about 100 miles per hour. Since the loss of efficiency for a fine-pitch propeller, even down to half the pitch ratio of best efficiency, is not great, it may be taken that for flight speeds of 50 miles an hour upward, the balance of advantage lies definitely with the direct-coupled propeller; this agrees with experience. A point of interest in connection with propellers of comparatively fine pitch and somewhat reduced diameter, such as commonly in use to-day, is the fact that, with the engine opened fully out, there is very little difference between the thrust and the revolution speed, whether the machine is standing or in full flight—it is commonly reported that the revolution speed does not increase more than 10 per cent from "standing" to full normal flight speed—the thrust variation also is slight. This fact constitutes the only justification for the static test of aeronautical propellers, frequently resorted to when approximate data are required. There is no doubt that in a propeller of theoretically perfect proportion, or in an existing propeller, if fitted to a machine of less resistance, there would be a far greater response to flight speed variations. Actually, this is a case in marine propulsion where the propeller revolution recorder is commonly found to give more reliable readings than the ship's log.

8. *Relating to the Design of the Aerofoil.*—We shall now proceed to the discussion of the more detailed arrangements and structural features of the machine. First, the aerofoil. The pressure appropriate to least resistance we have already seen to be given by the expression[33] $0.32\ \rho\ V^2$ in absolute units, or $\dfrac{\rho V^2}{100}$ in pounds

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* The James Forrest lecture, delivered before the Institution of Civil Engineers on May 5th. Compare also the same author's paper on "Catastrophic Instability in Aeroplanes," SCIENTIFIC AMERICAN SUPPLEMENT, February 14th, 1914, p. 98.

[31] With the rotating engine in its present state of development the question of upkeep is not its most satisfactory feature.

[32] Report of the Advisory Committee for Aeronautics, 1912-13, page 94.

[33] Compare Figs. 17 and 18 and text. The constant 0.32 is empirical.

per square foot. Consequently if w is the weight (in flying order) the area required is $\frac{100\,w}{\rho V^2}$ as appropriate to least resistance.

The above is the whole basis of any initial "lay out"; there are many refinements, however, to be considered, which enter into the complete problem; the principal of these are:

The fact that part of w is a function of the aerofoil area—the quantity we are determining—means that the best area will be less than given by the foregoing expression. This point has been dealt with by me in "Aerial Flight," 1907,[19] vol. 1, §§ 171, 194, 195, 196; also more recently by the staff of the National Physical Laboratory.[20]

Beyond the above, the specification of flight velocity for any machine consists more often than not in the prescription of higher and lower limits rather than of a set fixed speed. Under these circumstances, the final values and proportions are based on a lay-out of graphs of resistances, thrust, etc., on the lines of the diagrams already given, Figs. 11 and 12.

It is evident from the general character of the resistance velocity curve, as shown diagrammatically in Figs. 11 and 12, that whereas considerable departure may be permitted from the normal velocity of flight on either side of the minimum without incurring appreciable increase in resistance, at the limits of the flight-speed range, the slope of the resistance curve is considerable, and there will be sharply defined points at which the resistance is equal to the maximum propeller thrust, and no liberties can be taken. It is important to note that at the maximum limit of flight speed the equilibrium of thrust and resistance is stable, whereas at the minimum limit the conditions are those of instability, so that should the machine at any time fall below the minimum, the aeronaut can only recover his power of flight by calling upon gravity to assist him—that is to say, by taking a downward course. If, as when near to the ground (or an obstacle), the downward course is not permissible, the machine will execute an undignified descent, to which the verb "to pancake" has been applied. The critical speed at which this will take place is not necessarily related to the critical "least velocity" angle of the aerofoil.

Briefly, for a given machine the extent of the flight-speed variation is a function of the reserve of thrust over the minimum resistance value, the absolute value of the limits being fixed by the load that the aerofoil is called upon to sustain. In the case of a high-powered machine, however, the lower limit may be prescribed by the critical angle of the aerofoil.

The choice between monoplane and biplane is, in the main, a question of constructional engineering; there is not a great deal to choose between the two from an aero-dynamic standpoint, but with equally good design the monoplane gives a slightly better lift/drift ratio. The interference effect of the two members of a biplane aerofoil has been studied by many investigators. Langley showed, about 1890, that with superposed planes (aspect ratio = 4) the interference was not serious when separated by a distance equal to their lesser dimension. The results of a more recent investigation by the staff of the National Physical Laboratory are published in the report of the Advisory Committee for Aeronautics for the year 1911-12 (page 73), from which Table IX has been taken. In addition to obtaining quantitative data for the particular aerofoil chosen (Blériot, aspect ratio = 4), an investigation was also made on the effect of staggering the planes. It is shown to be advantageous to arrange the upper foil in advance of the lower; thus the combination *a b*, Fig. 29, is of the same efficiency as the combination *a c*.

TABLE IX.—*Table of Multiplying Factors to Obtain Coefficients from the Coefficients for a Single Aerofoil.*

Biplane Spacing. Gap/Chord.	Lift Coefficient.			Lift/Drift.		
	6 Deg.	8 Deg.	10 Deg.	6 Deg.	8 Deg.	10 Deg.
0.4	0.61	0.62	0.63	0.75	0.81	0.84
0.8	0.76	0.77	0.78	0.79	0.83	0.86
1.0	0.81	0.82	0.82	0.81	0.84	0.87
1.2	0.86	0.86	0.87	0.84	0.85	0.88
1.6	0.89	0.89	0.90	0.88	0.89	0.91

Considering the aerofoil, whether monoplane or biplane, from a structural standpoint, and in investigating the strength of the aerofoil as a whole, it may be treated definitely as an inverted cantilever system. Thus, comparing the stresses in an aeroplane to the stresses in a cantilever bridge, we have the weight of the fuselage with its alighting chassis, motor, passengers, etc., the inverted equivalent of the supporting reaction on the central pier of a cantilever girder. We have the air-pressure force, by which the said load is sustained, distributed along the aerofoil length corresponding to the weights of the outstanding members of the cantilever. We have a variation of pressure from point to point due to gusts, eddies, etc., corresponding to some degree to the movable loads representing traffic over the bridge. In the case of the aerofoil we have in addition something not represented in the analogy of the cantilever girder, i. e., the weight of the aerofoil itself directly supported by the pressure reaction; we may, however, regard this equal and opposite distribution of weight and pressure as superposed on the main system, and as not contributing to the stresses in the aerofoil members. So far as the analogy to the bridge holds goods, it is evident we have a well-known engineering problem which is capable of being treated by well-known methods. In the calculation of stresses of the aerofoil members two alternative methods are in current use; in the one the aerofoil struts are treated as pin-jointed members, by the usual truss-girder construction; according to the other method, in place of the hypothesis of the pin-joint, we have the hypothesis of continuity in the main longitudinals. The first and simpler method has been used by several firms for many years past, and gives results, which, under ordinary conditions, are very much on the safe side; the second method has been developed during the last few years by the National Physical Laboratory,[21] and has been adopted by the Royal Aircraft Factory, and more recently by other manufacturers.

On the pin-joint hypothesis the stresses are solved by the well-known graphic stress diagram; the alternative method is considerably more complex; reference should be made to the report cited. It is well to remark that though the pin-joint hypothesis gives results usually on the safe side, the extent of the factor of safety so introduced is not one that can be relied upon, and may in special cases be even negative. It is hardly necessary to point out that the more important and vital the problem, the less appropriate become methods of an approximate and inexact character.

9. *Resistance of Struts, Wires, Wheels, Etc.*—The question of the resistance of components, such as are commonly embodied in the design of existing machines, has been studied experimentally at the National Physical Laboratory, at the Aerodynamic Laboratory at Göttingen, and by Mr. F. Eiffel, in Paris. A few results relating to strut sections are given in Fig. 30. The graph *a a* is a plotting from National Physical Laboratory data,[22] relating to the sections *a*, representing one of the best forms tested; graphs *b* and *c* relating to sections *b* and *c* as determined by Mr. Eiffel.[23] In Fig. 30 ordinates represent resistance coefficient in absolute units, also in terms of normal plane (the normal plane unit being that of maximum section). In Fig. 30*b* are given two strut sections designed at the Royal Aircraft Factory. These were reported upon by the National Physical Laboratory as giving less resistance for given strength than a number of others submitted. Approximately, strength for strength, these sections gave one fourth the resistance of struts of circular form.[24]

The resistance of wires and ropes has been investigated both by the National Physical Laboratory and by Prof. Prandtl of Göttingen; the position may here be summarized by saying that the resistance of a rope or stranded cable, at right angles to the direction of motion, is virtually equal to that of its projected area in normal plane. The resistance of smooth wires is about 20 per cent less. Both these results only hold good above a certain minimum value of lV, which may be taken at about 1.5, thus at 100 feet per second the rule may be taken as applying to cables or wires down to about three sixteenths inch (= 0.015 foot diameter).[25]

Another interesting set of determinations, for which we are indebted to the National Physical Laboratory, is that relating to the resistance of alighting wheels; these have been tested both in respect of resistance and lateral reaction.[26] The direct resistance of a 26-inch wheel fitted with a 2½-inch pneumatic tire appears to be equal to about a third of its projected area in terms of equivalent normal plane, the projected area being taken to be that of the tire itself. For fuller information reference should be made to the memorandum cited.

10. *Vertical Surface.*—One of the quantities of great importance in connection with the type of stability known as rotative or spiral stability is that of vertical surface. It is of great importance to be able to compute with accuracy the effective distribution of vertical surface in any machine, and of recent years considerable attention has been devoted to, what we may term, the "valuation" of accidental vertical surface. For example, every vertical or inclined strut has a certain directive value, which may be expressed in terms of vertical surface; the alighting wheels, especially if of disk form, represent considerable areas of the equivalent vertical surface; even the fuselage (the stream-line body or car) has its equivalent value as vertical surface. It was pointed out by me some years ago[27] that a screw-propeller moving other than axially experiences a considerable lateral force. More recently Mr. T. W. K. Clarke has called attention to this action, and to the importance of considering the propeller in its capacity as effective vertical surface. It appears from Mr. Clarke's investigation[28] that the propeller equivalent in terms of vertical surface is a very large and serious factor, and one that under no circumstances should be ignored. The memorandum in question is worthy of careful consideration by all engaged in the design or construction of flying machines.

A point that should not be overlooked is that the propeller value in the sense under discussion is totally different when under power and when dragging or stationary; this suggests the desirability of locating the propeller as near to the center of gravity (in the fore-and-aft sense) of the machine as conveniently possible.

11. *The Dynamic Load Factor and Factor of Safety.*—A matter of importance, and one of a controversial nature, is the factor of safety necessary in order to take care of the many and varied conditions met with by a machine in flight. In the simple case of a machine in horizontal flight in calm weather we know that the load supported by the aerofoil is the weight of the body of the machine and its associated parts, but not including the aerofoil itself, whose weight is directly distributed over the pressure surface; also we know that in the various evolutions a machine is called upon to perform, the stresses may considerably exceed the normal, and that variations of effective load are experienced, due to wind-gusts, which it is quite out of the power of the pilot to prevent. Excluding for the time being the latter, we are clearly able to define the worst that the pilot is able to do and specify the factor by which the normal stresses must be multiplied in order to represent the actual stresses; conversely, we may specify arbitrarily a factor of safety, and we may tell the pilot just what he is permitted to do, and just what he cannot undertake without risk. Taking, in the first instance, the assumption that the pilot is allowed to do his worst—he is to be allowed to try to wreck his machine. There are two ways in which he can operate; first, he can drive his machine at the highest possible speed and suddenly alter his elevator to the position corresponding to the lowest possible speed; alternatively he may take sharp turns involving heavy banking. Now the highest possible speed is the limiting velocity which the machine will acquire falling head first vertically; this, with machines as at the present day constructed, may be estimated at about 140 to 150 miles an hour. The lowest velocity in the present sense is the velocity at which the aerofoil is meeting the air at its critical angle (the lowest velocity capable of giving a pressure reaction equal to the weight); this may be taken for our purpose as 40 miles an hour. If, when falling vertically at 140 miles an hour, the pilot with absolute suddenness jerks his elevator into position corresponding to 40 miles an hour, the reaction brought to bear on his aerofoil is $\left(\frac{140}{40}\right)^2 W$, that is to say, approximately twelve times the weight of the machine. In practice, for the figures given the maximum load would be diminished, since the elevator cannot be moved with absolute suddenness, and, if it were, the machine could not answer the elevator and alter its attitude to the line of flight immediately. It is probable, on the basis of the figures given, that 10 W is the maximum effective load that could under any circumstances be brought to bear.

In the case of severe banking, if the machine be banked to an angle θ, the resultant of the weight and centrifugal force is the value $W \sec \theta$. I have frequently made estimates of the angle of banking when a pilot has been making a steep spiral dive; the angle rarely exceeds 60 degrees or 70 degrees. Taking 70 degrees as the maximum, the stresses in the machine will correspond to a load equal to 3 W.

From the foregoing it would appear almost certain that in calm weather the pilot, if asked to do his worst, cannot in any manner reach or exceed ten times the stresses due to the static load.

Let us take what may be considered an extreme gust.

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[19] Constable & Co.

[20] Report of the Advisory Committee for Aeronautics, 1911-12, page 76.

[21] Report of the Advisory Committee for Aeronautics, 1912-13, No. 83.

[22] *Ibid.*, 1912-13, page 111.

[23] "Resistance of the Air and Aviation," page 184.

[24] Report of the Advisory Committee for Aeronautics, 1911-12, page 96.

[25] Compare Memoranda 40 and 75, Reports of the Advisory Committee for Aeronautics.

[26] Memorandum 74, Report of the Advisory Committee for Aeronautics, 1912-13.

[27] *Engineering*, February 26th, 1909.

[28] Presented to the Advisory Committee by Mr. Mervyn O'Gorman. Memorandum 80, March, 1913. Report, 1912-13.

The machine enters air, or is struck by a gust represented by a change of velocity equal to half the flight-speed. Assuming the machine has time to swing to its appropriate relative direction under the new conditions, a simple resolution of velocity shows that the worse condition is that in which the direction of motion of the gust is directly opposed to that of flight; in such a case the relative velocity of the machine becomes 1½ times normal, and the effective load on the aerofoil will be $(1\frac{1}{2})^2 = 2\frac{1}{4}$ times normal. In case of the machine being struck by a sudden gust or squall, the load will be considerably higher, but still does not approach the figure 10 obtained on the basis of the pilot suddenly "flattening out" when at maximum speed.

It is evident from the foregoing that a flying machine in the course of its normal usage is liable to stresses many times greater than that of its normal load, and the frequency of these stresses, and the total number of times they occur in the life of the machine, will be related to their magnitude by some empirical law for any given class of service. In such a case it is evident that the term "factor of safety" does not carry its ordinary meaning; if, for example, in the lifetime of a fleet of 100 machines the stresses reach six times normal once, and five times normal, say, ten times, and four times normal, say, 150 times, it will be certainly sufficient and proper if the designer works to six times the normal load for his elastic limit without using any factor of safety in the accepted sense at all; to do otherwise would be to burden the whole 100 machines with a weight of superfluous material without justification. Whether under these conditions we continue to employ the term "factor of safety" or not[44] the aeronautical designer must bear clearly in mind that in his particular case his factor has a double function, namely, both to give the margin of strength and durability needed under ordinary conditions of flight, and to provide for abnormal conditions of stress, occasionally, even almost to the theoretical limit of the strength of the structure.

In Memorandum No. 96 of the Advisory Committee (not yet included in an annual report) the matter is fully considered, and the extreme probable values are estimated as follows:

Nature of Contingency.	Computed Dynamic Load-factor
Gusts	4.0
Banking	1.4
Flattening out	8.0
Looping[45]	4 to 5

In the report in question[46] the recommendation is made that a factor N be adopted in design not less than 5 or 6, this being considered sufficient to take care of anything likely to happen to a machine with reasonable and proper pilotage. Tests and calculations of the wing-spars of different existing machines gave the following results:

Type.	Value of N.	How Determined.
A	1	By experiment.
B	4	Do.
C	5	By calculation.
D	3	Do.
E	3	Do.
F	4	By experiment.
G	7	By calculation.

The Royal Aircraft Factory have adopted a factor somewhat greater than that recommended in the Memorandum in question; a machine (G in above table), of which the aerofoil was tested to destruction, actually recorded 8.4.

In connection with the subject of aerofoil structure it is to be observed that the stress distribution varies considerably under different conditions, namely, at different angles of attack. Referring to Fig. 15, it will be noted that the aerofoil structure commonly includes two longitudinal members, front and rear, respectively, and the proportions of the load borne by each depends upon the position of the center of pressure and varies with its displacement, which can only be ascertained from experiments on a scale model of the aerofoil itself. This fact needs consideration when computing the maximum stresses on the members in question and the aerofoil structure as a whole.[47]

The calculation of the aerofoil structure not only comprises the resolution of the main lifting-force distribution, as already discussed, but also entails the calculation of the longitudinal stresses due to line-of-flight, or "drift" forces. These may be quite moderate under normal flight conditions, but may become far more severe at abnormally high speeds.[48] The treatment of this problem does not offer any serious difficulty; it is to-day generally considered the best practice to provide for the edgewise strength of the wing by its own internal diagonal bracing.

(To be concluded.)

The Darwinian Theory Denied*

In the course of his opening address at the meeting of the British Association for the Advancement of Science, at Melbourne, Australia, on the 14th, Prof. William Bateson, the president of the association, discussed the theories of Darwin, and his conclusions controverted the generally accepted theories of evolution. His address was, in part, as follows:

"We must begin seriously to consider whether the course of evolution can at all reasonably be represented as an unpacking of an original complex, which contained within itself the whole range of diversity which living things present.

"As we have got to recognize that there has been an evolution, that somehow or other the forms of life have arisen from fewer forms, we may as well see whether we are limited to the old view that evolutionary progress is from the simple to the complex, and whether, after all, it is conceivable that the process was the other way about. When the facts of genetic discovery become familiarly known to biologists and cease to be the preoccupation of a few, as they still are, many and long discussions must inevitably arise on the question, and I offer these remarks to prepare the ground.

"I ask you simply to open your minds to this possibility. It involves a certain effort. We have to reverse our habitual modes of thought. At first it may seem rank absurdity to suppose that the primordial form or forms of protoplasm could have contained complexity enough to produce the divers types of life. But is it easier to imagine that these powers could have been conveyed by extrinsic additions? Of what nature could these additions be? Additions of material cannot surely be in question. That which is conferred in variation must rather itself be a change, not of material, but of arrangement or of motion.

"The invocation of additions extrinsic to the organism does not seriously help us to imagine how the power to change can be conferred, and if it proves that hope in that direction must be abandoned, I think we lose very little. By the rearrangement of a very moderate number of things we soon reach a number of possibilities practically infinite.

"That primordial life may have been of small dimensions need not disturb us. Quantity is of no account in these considerations. Shakespeare once existed as a speck of protoplasm not so big as a small pin's head. To this nothing was added that would not equally well have served to build up a baboon or a rat."

Prof. Bateson pointed out that a great body of experiments, made and making according to the method laid down by Mendel, tended toward the theory that variation is produced by a loss of normal qualities. "I have confidence," he said, "that the artistic gifts of mankind will prove to be due not to something added to the make-up of an ordinary man, but to the absence of factors which in the normal person inhibit the development of these gifts. They are almost beyond doubt to be looked upon as 'releases' of powers normally suppressed. The instrument is there, but it is 'stopped down.'" He added:

"As the evidence stands at present, all that can be safely added in amplification of the evolutionary creed may be summed up in the statement that variation occurs as a definite event, often producing a sensibly discontinuous result; that the succession of varieties comes to pass by the elevation and establishment of sporadic groups of individuals owing their origin to such isolated events, and that the change which we see as a nascent variation is often, perhaps always, one of loss.

"Modern research lends not the smallest encouragement or sanction to the view that gradual evolution occurs by the transformation of masses of individuals, though that fancy has fixed itself upon popular imagination. The great advances of science are made like those of evolution, not by imperceptible mass improvement, but by the sporadic birth of penetrative genius. The journeymen follow after him, widening and clearing up, as we are doing along the track that Mendel found."

Not only did Prof. Bateson reverse the current notion of evolution, but he said that natural evolution accounted scarcely at all for the diversity of species; that the doctrine of the survival of the fittest was unassailable so long as it was applied to the organism as a whole, but that Mendelism had shown that in its application to the parts, to details of specific difference, to the spots of the peacock's tail, to the coloring of an orchid flower—details in which the potency of natural selection had been urged with the strongest emphasis—it was quite untrue. While favored races survived, that truism "scarcely at all accounts for the diversity of species."

He declared that he could not disguise his sympathy with the effort of the Mendelian extremist Lotsy that all variation might be due to crossing. He added that without experimental breeding it was certain that "we are merely guessing when we profess to distinguish specific limits and to declare that this is a species and that a variety. The only definable unit in classification is the form springing from similar germ cells which breeds true."

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[44] This point may perhaps be emphasized by the use of some qualified expression such as "dynamic load-factor."

[45] Estimated by the not in original report. The basis of this estimate is the plugoid chart, Fig. 16, the dynamic load-factor is given by the height H in terms of H_0, or in the case of looped paths numbered 8 to 12 the value of $\frac{H}{H_0}$ varies from 3.6 to 5.5.

[46] If this factor N cannot with propriety be termed a factor of safety, I suggest the term "factor of contingency"—i. e., the factor of contingency requires to be the equal or greater than the dynamic load-factor for which it makes provision.

[47] Reference should be made to the Report 96 cited.

[48] When a machine is diving head first downward at or near its limiting velocity the drift load is considerably greater than half the weight of the machine.

* The Address of President Bateson, of the British Association for the Advancement of Science, at Melbourne.

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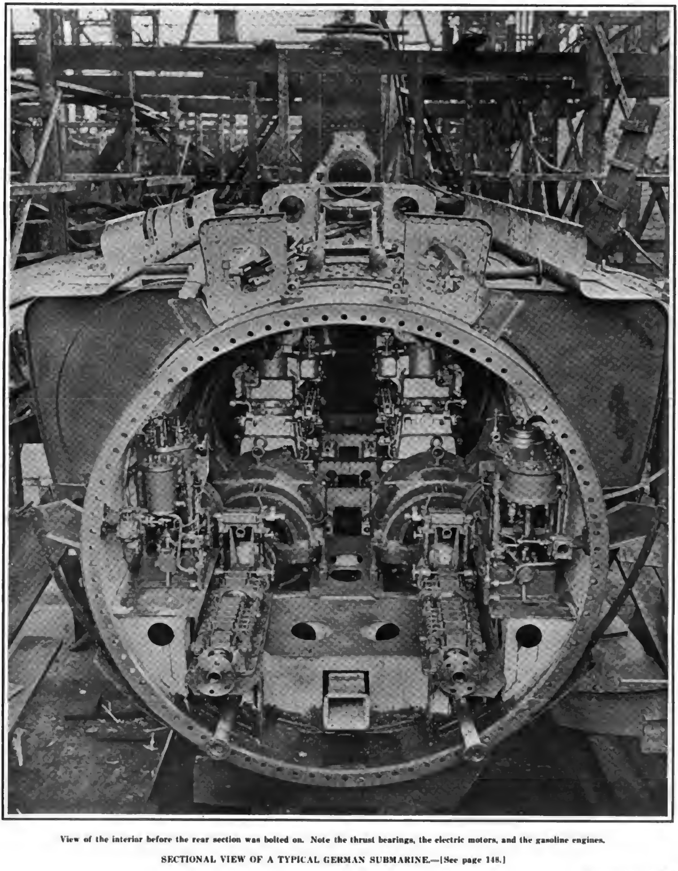


View of the interior before the rear section was bolted on. Note the thrust bearings, the electric motors, and the gasoline engines.

SECTIONAL VIEW OF A TYPICAL GERMAN SUBMARINE.—[See page 148.]

Germany as an Industrial Power

An American Manufacturer Discusses the German Inspiration and Reviews Its Commercial Growth

After a tour abroad for the purpose of observation and study of foreign commercial and industrial methods Frank A. Scott of the Warner & Swasey Company gave the results of his investigations in a comprehensive address before the Cleveland Advertising Club. His attention was particularly directed to the methods and causes that have made Germany a world-wide power in commerce, and his remarks are of particular interest at this time. The *Iron Age* published lengthy abstracts from the address, from which the following are derived.

The German empire that we now deal with, and the German empire that is going to teach us, is teaching us, many things, and that will be the most interesting subject for business men and statesmen during the next twenty-five years, dates from 1871. I want to give you a suggestion of the size of Germany as related to a number of powerful European nations, and the United States, and the conditions under which that population lives. Russia, which has the largest area of any of the European nations, has 8,555,555 square miles. Germany comes next; but note the difference—208,000 square miles. Germany has an area about equal to Indiana, Illinois, Wisconsin, and Michigan. France has 207,000 square miles, and England 121,000—that is, the British Isles. Russia has a population per square mile of about 19; the United States (and you will note that our population seems scant) has 32; France has 191, but Germany has 311. Just as soon as we know that, if we know anything about the Germans, we know we have a condition of compression which is going to grow so great that it must find relief.

And that is where the difference in policy came between Bismarck and the present Emperor. Bismarck had unified Germany. His mind rested largely on the idea of a centralized and a unified Germany; whereas the present Kaiser has seen the need for expanding the boundaries of his country, for finding places where the force and energy that have been developed by the German schoolmasters can find expression under other suns than in Germany.

GERMANY FEEDS ITS OWN PEOPLE.

Such a population as 311 per square mile presents a great problem in the feeding of the people. In most European countries where the population is so dense, the importation of food products is a necessity. England is a very marked example of that. England imports grain from a number of countries. She imports meat largely from this country and from Australia; her dairy products from Denmark, Finland, Norway, and Sweden. Germany has developed her power to feed her people within herself, and has applied the wonderful science of that country to the problem of taking care of the population within her own boundaries.

I want to give you the inspiration of the agricultural figures of Germany, that show by what means she has accomplished this. In 1881 Germany raised of wheat 1,397 pounds per hectare, about 2.47 acres; in 1913, 2,596 pounds, an increase over the same acreage of 85.8 per cent. Rye in 1881, 1,199 pounds; in 1913, 2,100 pounds—increase 75.2 per cent. Oats in 1881, 1,331 pounds; in 1913, 2,409 pounds—increase 81 per cent. Potatoes in 1881, 11,800 pounds; in 1913, 17,446 pounds—increase 47 per cent.

Perhaps we would be interested to see how these figures compare with those for the United States. During the same 30-year period our yield of wheat per acre changed from 13.1 bushels to 13.9 bushels; of rye, from 13.9 bushels to 16 bushels; of potatoes, from 91 bushels to 93.8 bushels. The corn acreage of our country has increased tremendously in the 30 years, but my recollection is that we produce just as many bushels per acre to-day as we did 30 years ago.

You gentlemen are perhaps thinking that our conditions are different; that there is no reason in the United States, or at least there has been none, for the adoption of the intensive methods of cultivation which Germany has adopted. And that is so. I want to say, after quoting the American figures, it probably has been better for us with our tremendous acreage and with the great amount of virgin soil that was available to the American farmer, to handle a vast acreage, but without such intense cultivation. In fact, with our scanty population, such intense cultivation is impossible. But the German figures are interesting to us as showing what can be done by a diligent nation on a naturally poor soil in rigorous climate.

Germany has met these agricultural problems by applying to them scientific methods in her drainage, in irrigation, and particularly in the use of commercial fertilizers. The consumption of commercial fertilizers in Germany increased from 1,600,000 metric tons in 1890 to 6,000,000 tons in the year 1910. There is an interesting thing about these commercial fertilizers. The German pig iron production has increased tremendously in these twenty years. By what is called the Thomas-Gilchrist process they were able to use high-phosphorus pig iron in steel manufacture, and the resulting slag was very rich in phosphorus. Grinding that up gave a product that they called Thomas phosphate flour; and to-day millions of tons of phosphate flour are used on the lands of Germany. So she not only increased her ability to produce steel but increased her ability to produce potatoes by using the invention of Thomas and Gilchrist.

WONDERFUL GROWTH OF TRADE.

The population of Germany about the time of the formation of the empire was 44,000,000 approximately. To-day it is 60,000,000. This immense growth in population, and particularly the crowding of the people into the cities—for in that respect Germany has had the experience of all civilized nations—has necessitated the development of industries to employ those thronging workmen. So Germany is changing as other nations are, from an agricultural to an industrial nation, but she has responded remarkably to this need.

Because my subject deals particularly with foreign trade, I am going to confine the figures of growth to a few dealing with the exportation of industrial products. The highest on Germany's list, the product in which she has advanced most, from 1883 to 1912, is machinery of all kinds. The value in 1887 of machinery exported was 52,800,000 marks; in 1912 it had risen to 630,300,000 marks. Coarse and fine iron products rose from 96,000,000 marks in 1887 to 581,000,000 marks in 1912. Coal exports from that small country rose from 79,900,000 marks in 1887 to 436,000,000 marks in 1912. Coke exports in 1887 were 9,000,000 marks; in 1912 they were 126,000,000 marks. Cotton, woolen and silk goods increased from 261,000,000 marks in 1887 to 966,000,000 marks in 1912. These figures explain to all of us who have been in countries where we seek foreign markets why we find the German there, and we do find the German there, and he is there very strongly entrenched, and he deserves it.

THE GERMAN MERCHANT EVERYWHERE.

I remember years ago, I think it was 1907, when my interest in the German was first excited. It was because in Mexico I noticed in every one of the twenty-four cities and towns visited on the trip, if you inquired for the hardware merchant or the leading man who could speak English, you were pretty sure to find he was a German. Their volume of business in Mexico, I think, is not equal to that of Great Britain as yet; I will say it again, *as yet*.

In 1887 Great Britain stood first in pig iron production, the United States second, and Germany third. To-day the United States is first, with 31,000,000 tons in 1913, Germany second, with 17,000,000 tons, and England third, with 10,000,000 tons. The total pig iron production of 1913 of the world was estimated at 75,000,000 tons, and of this Germany, with her poor ore, produced one fourth. To-day Germany ranks second in steel production, third in coal production, third on 208,000 square miles in the production of wheat and rye, and second only to the United States in the length of her railroads.

Within the period of 25 years, the percentages of increase in foreign trade of the three leading foreign export nations were as follows: United States increased 208 per cent, Germany 185 per cent, United Kingdom 119 per cent. And those are the figures with which I want to prove my point, that to-day we must look, not to our former teacher, England, for inspiration in foreign trade, but to Germany. And we shall have to work very hard, in my opinion, even with a gain of 208 per cent compared with 185, to retain our position during the next 25 years. And all of us who have an opportunity to contribute to that will have to take the subject seriously, or when we read these figures 25 years from now, Germany will be at the head and not the United States.

THE SCHOOLMASTER AND THE DRILLMASTER.

I think every student of the industrial problem in Germany will agree in the great advantage which Germany has in her military training. The influence of two things it seems to me is particularly marked in Germany—the German schoolmaster and the German drillmaster. Of course, to begin with, Germany is a Christian nation. I think that helps, and I am founding everything else on that. You know that until within a few years most of the men who grew to maturity in Germany served in the army. Now their population is increasing so rapidly that they do not have to be as severe in the selection of men. Of the total number offering they select fewer to-day than they did some years ago; but nevertheless the great bulk of the male population of Germany for a hundred years has been trained in the German army. I believe you can see in every man in that country the effect of training in habits of discipline, self-respect and honesty. In that particular Germany has a lead over both England and the United States, and this probably we will be many years in overcoming, if we ever adopt such a system.

I have read and I have heard it said that this tremendous growth of German industry and commerce constitutes a menace to American trade. Personally I do not reason that way. Opposition strengthens us. Our competitor is our helper. I would prefer to find an inspiration in what Germany has done rather than a menace. If the Germans are expanding their foreign trade at the expense of other nations, it is because they, more than any other nation, have planned their work. The question is, Did they attain this great force as a commercial and industrial nation through, for instance, great natural resources? The answer must be, No.

COMMAND OF THE SEAS.

I have shown you that Russia and the United States both have natural resources greatly in excess of Germany. Have the Germans reached their position by reason of the fact that they were able to qualify under Sir Walter Raleigh's doctrine that "whoever commands the sea commands the trade"? The answer has to be, No. Germany has never commanded the sea. It has been true up to this time at any rate, according to my reading of history, that whoever commands the sea commands the trade. When Portugal commanded the sea she commanded the foreign trade; while Holland commanded the sea she commanded the foreign trade. To-day England commands the sea, and she is the greatest export nation at this time. Germany is second in sea power, and she has never tested her naval strength with any naval competitor. It may be that the future has in store such a test, and if it comes and Germany goes to the front in that test, Germany will surely command the world trade. We will take whatever position is assigned to us at that time.

I am not speaking to-day as a jingo, but speaking only as an American business man may. I want to quote to you a paragraph from a pamphlet written by Dr. Karl Helfferich, director of the Deutsche Bank, which he wrote in celebration of the present Kaiser's twenty-fifth anniversary. This deals particularly with the relation of the German naval power to foreign business:

"German economic life is conscious of being strong enough, in times of peaceful competition, to maintain and strengthen its position. But the temptation for a strong nation to make use of its political and military resources against a weaker one in the struggle of economic competition has at all times been very great. The numerous wars over commerce in the history of the world give evidence of this. All the progress of culture and civilization in the life of the nations must not deceive us and cause us to forget that any too sharp divergence in the development of economic strength and political power creates a tendency toward a violent explosion and re-establishment of equilibrium. Knowing this, Germany, which is compelled by its geographical position and its experience in history to maintain a land army equal to all contingencies, had also to decide to protect its ever-growing and expanding economic relations over the seas by building a navy strong enough to nip in the bud any temptation, on the part of any enemy, to crush our economic competition by force. Our navy, the creation of our Emperor, is, in this sense, the keystone in the mighty system to which is due the extraordinary development of wealth in Germany, and which to-day constitutes the basis for the existence of the German people."

I give you that paragraph to think about some time when you are reading a discussion on the one battleship programme in Congress or when you have presented to you what was presented to me the other day: the idea of an agitation to do away with all appropriations for battleships and have the government contribute the amount to sustaining and educating babies in the United States! That is not a joke; there is such an organization in existence in this country.

AMERICAN AND GERMAN ADAPTABILITY.

Many American manufacturers who have good foreign trade have treated it as most of us do our greatest blessings, as a thing to be accepted as a matter of course, without thankfulness to the giver, and to be forgotten and neglected as soon as anything nearer at hand attracted attention.

American goods for the most part have been designed and manufactured to meet the American market, and when we ship them abroad, we ship them according to American design and manufacture, and to meet American standards. So long as they meet the need of the foreigner, and so long as he is unable to supply that need from another source, in our lines, of course, he buys them from us; but as soon as he can find some one who will meet his wishes in the design and manufacture of the goods, he finds a new market.

Germany deserves first rank in her willingness to meet the wishes of the customer, in her versatility in reaching the market and in satisfying the customer, and in the interest which she shows in all the questions which pertain to the economic life and development of the customer. I am sure any one in this room who has been in the Far East or in South America, or in Mexico, or any of the countries in which German competition is now becoming very strong, will agree that in shipping facilities, in banking facilities, in social touch with the customers, Germany is rapidly becoming the leader.

Price Collier, referring to the English and not to the Americans—but it would apply almost as well to the American manufacturer as to the English—said: "The attitude, wherever you find him throughout the world, is, 'This is my way,' and it is the right way, and it is God's way, and God is the God of the English established church.'" To some degree that has been the attitude of American manufacturers in meeting their foreign customers.

FOREIGN TRADE SYSTEMS.

Germany has followed the absolutely paternalistic system in developing her foreign trade, and England has followed the individualistic system, and we have very largely followed England. We do not demand to the degree that the Germans do that the government throw the whole weight of its influence and power into the development of our foreign trade. The Germans have assisted their development by their consular system, foreign steamship lines, foreign banking systems, rebates in freight rates on government railroads, when those were necessary to enable the manufacturer to reach a foreign market. Those things we have not had, as coming from our government, except the assistance of our consular service, and most of those things we would not want from our government.

The kind of prosperity that this development has brought to Germany is material prosperity. I realize that I am dealing only with material prosperity, and that to sneer at commercial prosperity is now regarded not only as safe, but as patriotic. But this does not change the fact, nor will it ever change the fact, that commercial prosperity means work for the idle, food and shelter for the needy, hospitals for the sick, schools for the ignorant; and whatever attitude of mind we and the remainder of the American public may get into to-day on the subject of business, we will pass beyond that and realize that, while we want it conducted righteously, yet it must be conducted and it will be conducted.

It seems to me that in this uncertain and quiet time we must make our plans for the busy time that is absolutely sure to follow. Very little that is unpatriotic is being done in this country. Most of the agitation that disturbs us, and that we fear, is by men who believe they are doing what is right. We as Americans cannot believe that America has come to the end—that she will never be greater than she is to-day. We know that we will be greater and that we will be better, and that the successes of the future will be founded upon the successes of the past. And that is why at this time personally I am looking everywhere for inspiration. I believe if there is any danger in our own country, from our own acts, or to our own country by reason of the processes that are going on in other nations, the American business man and the American working man unitedly will find in any peril that menaces us only opportunity.

Aircraft on the Defensive and Offensive

FRANCE is zealously striving to adapt the flying machine to aggressive warfare. Among others, there were begun at the flying field at Buc in October, 1913, tests before a military committee with the so-called "Air Craft Hunter" of Lieut. Mailfert. The flying machine, which was already exhibited at the last Aeronautic Exhibition in Paris, is a Nieuport monoplane of 100 horse-power. It contains in its *fuselage* a shot-sieve or a projectile thrower, an arrangement which, when the pilot sets it in action, strews the underlying ground with two thousand shot. An aiming arrangement is said to be at hand. On the flying field a flying machine was represented in actual scale by means of a disk. Lieut. Mailfert rose in his machine to a height of 2,000 meters and flooded the target with his projectiles. The disk was riddled with many bullets. Then free balloons were released, against which also Mailfert brought his shot sprinkler into action. He succeeded in causing two balloons to sink.

Another kind of aggressive flying machine, the so-called "Zeppelin-Hunter," was put to trial last summer, according to the Paris *Journal*. With its own weight reduced to a minimum, it had to carry an armor of 60 to 70 kilogrammes to protect both the pilot and the more vulnerable parts of the machine. It is intended to provide the flying machine with a light machine gun, which can perforate the Zeppelin hulls with rapid fire shot and ignite the gas.

In January, 1914, an experiment took place also in Villacoublay, with a new armored flying machine, which was built and provided with a rapid-fire gun, according to the directions of the heads of military aeronautics. The ordnance, presumably a machine gun, is claimed to have signal striking capacity. The flight, however, which the pilot, Espaner, effected, with the new aeroplane, was not very fortunate.

The French papers emphasize that in future all French military air craft, except the school machines, will be armored to protect them against hostile fire. They may be divided into the following kinds:

1. Armored monoplane for reconnoitering artillery and cavalry. Minimum velocity, 120 kilometers per hour.

2. Armored biplane for reconnaissance work of the general staff at great distances. Minimum velocity, 100 kilometers per hour.

3. Armored biplane which, provided with machine guns, etc., shall destroy hostile aeroplanes and airships. Minimum velocity, 120 kilometers per hour.

4. Large aeroplanes with more seats for special service.

The Paris Aeronautic Exhibition last fall showed a special number of armored aeroplanes. The armor protection extended not only to the pilot and observer, but also to the provisions, the rudders, the measuring instruments and especially the propulsion system. The aeroplanes not intended for aggressive warfare were for the most part provided with wireless apparatus.

The improvement in the possibility of observation was shown at Villacoublay late in November, 1913, on a new kind of aeroplane in which the seat for the observer is placed forward, directly under the screw propeller. Deputy Girod, piloted by Gobé, flew over the field several times and made effective observations. The capacity for observations from this position is without doubt greater, still the observer in this advanced position is more exposed to hostile fire, and above all is incapable of taking charge of the controls of the aeroplane in case of failure of the pilot.

At Farnborough in England last year a trial of sharpshooting from aeroplanes was held. A military biplane was provided with a machine gun and ammunition; this gave, from an elevation at 120 meters, 20 shots directly downward. As to its striking capacity and effect, nothing has been reported; the recoil from the shot was without notable influence on the equipoise of the aeroplane.

Also a Birmingham society instituted at Bisley sharpshooting at an aeroplane with a machine-gun. The 25-pound, air-cooled machine-gun invented by Col. Lewis was fixed on a tripod on the aeroplane framing; on a tripod was also placed the movable seat for the protection of the aviator. Out of thirty shots at a target space of 20 feet, 11 hits were scored. From what elevation the aeroplane fired has, however, not been reported, nor the velocity of the air craft, nor the kind of target arrangement.

A sighting arrangement for machine guns on air craft has lately been patented. The machine gun is fixed between the legs of the observer sitting forward and having charge of the gun. The aviator sits elevated behind the observer. The forepart of the aeroplane is covered with a hood which carries on top a notch and sight. When the target is in sight the observer calls to the pilot and adjusts the sighting arrangement for distance and altitude. The aviator directs the aeroplane at the target by one of the rudders in conjunction with the notch and sight. When the observer perceives that the direction coincides he promptly fires.

An aeroplane projectile with rear rudder has been made in England. A tube extends lengthwise through the middle of the cylindrical projectile, filled with explosive. It carries, in front, trigger pins and percussion caps separated by an interspace, and having well to the rear an ignition charge. Both parts are secured by bolts fixed to the aeroplane frame, and, through the projectile, interlock in the tube, and so protect the aeroplane from destruction by its own discharge due to hard landing, shocks, etc. The part of the tube extending to the rear of the projectile carries the tail rudder. The projectiles hang on two hooks perpendicular to the floor of the aeroplane frame. When the projectile is to be thrown, the aviator establishes a special relation between the measured altitude and the velocity of flight, aims at the target, and, by means of a hand lever, releases the supporting arrangement of the projectile. The projectile, now free, sets itself point downward by means of its tail rudder. Since the two safety bolts have remained behind in the aeroplane, the igniter is in working condition, and when the projectile strikes, the trigger pin pierces the percussion cap, ignites the ignition charge, and this sets off the explosive charge of the projectile.

Shooting at aeroplanes was carried on last year in the camp at Chalons. A kite seven meters in width by six meters in length, represented an aeroplane and was towed by an automobile and wire cable with a velocity of 60 kilometers per hour. It was fired at by two squads of infantry of fifty men each, at a distance of 800 to 900 meters. Out of nine hundred shots (nine cartridges for each man) twelve hits were scored on the kite, that is 0.12 for each man. A second shooting, with the same number of men, at a small kite, measuring 1.5 meters broad by 1 meter long, gave 0.5 shot per man, but at a distance not reported. Machine guns were trained against the same target, but with less effect.

A Spanish aeroplane was hit last November by Moroccans. Capt. Barreiro and Lieut. Gil-Rios undertook, in a reconnaissance on a military biplane, to observe the position of the insurgents. In this they were subject to fire by a group of hostile troops which had got footing on Conical Mountain. The lieutenant was grievously injured by two shots, the captain was wounded by one shot. It was possible for the officers, in spite of their wounds, to fly back again to their own camp—a proof, therefore, that even effective fire does not always put an aeroplane out of commission, and that an energetic aviator, even in spite of his wounds, will often carry out his orders.

[Translated for the SCIENTIFIC AMERICAN from *Kriegstechnische Zeitschrift*.]

New Arrangement of Mirrors for Lighthouses, Etc.

E. CANNEVEL describes a new arrangement of mirrors for lighthouses in *Comptes Rendus* that greatly increases the reflecting surface. This arrangement consists of a stepped mirror, which is composed of a number of parabolic and annular elements, and is combined with a spherical mirror. The different paraboloidal fragments all have the same focus, and part of each projects rays directly to infinity, while the other part, masked by the succeeding step, also sends the rays to infinity, but by way of the ring connecting them, the angle of incidence making the rays pass through the spherical mirror placed at the bottom of the truncated, circular stepped mirror. This arrangement of mirrors increases considerably the reflecting surface and, since the images projected by the rings are not exactly superposed, it may be used with filament lamps. Difficulty having been experienced in making the mirror in metal, use is made of glass silvered electrically by kathodic projection under a bell, which, after being evacuated, was filled with hydrogen under pressure in order to prevent oxidation of the metal.

Oscillating Spark as an Economic Source of Ultra-Violet Light

EXPERIMENTS have been made with a view to obtaining the most suitable conditions for the production of ultra-violet light from the spark of an oscillatory circuit, and, in particular, of the "mean ultra-violet rays" used in sterilization and photochemical reactions. It is found, says J. de Kowalski in *Comptes Rendus*, that the region of max. radiated energy is displaced toward the longer wave-lengths as the current in the oscillatory circuit is increased, but toward the shorter wave-lengths the greater the amount of energy consumed in the spark; its position and intensity varies also with the nature of the electrodes. The intensity of the "mean ultra-violet rays" increases as the frequency of the oscillations decreases. If a resonance transformer is used as the source of the oscillations a definite relation can be obtained between the number of sparks per sec., the capacity, and the frequency of the primary current, and thus the most economic conditions of working can be obtained.

German Submarine Boats

Interesting Details of Construction and Fittings

A Krupp submarine running at 12 knots on the surface.

The submarines of the "Germania" type, evolved and developed by Krupp, are the standard class of submarine in the Imperial German navy. The Krupp firm have always considered the "diving" boat to be the most efficient form of submarine, and it may be mentioned that their contentions as to its all round superiority are upheld by the German government naval authorities.

A typical Krupp submarine measures 120 feet in length, with a beam of 12 feet 2½ inches, and a draught of 12 feet 5 inches. The displacement on the surface is 225½ tons, and when submerged 280½ tons. The vessel is provided with two hulls. The outer has the lines of a torpedo boat, which with the high freeboard and superstructure serve to render the boat extremely seaworthy. The inner hull is divided into three longitudinal sections, being built up of three circular welded sections bolted together. This shell is of sufficient strength to enable the craft to withstand safely a water pressure equivalent to a sea depth of 265¾ feet. The space between the outer and inner hulls is subdivided into a number of watertight compartments, which contribute greatly to the safety of the vessel, since a number of these may be punctured without endangering flotability. The water ballast, oil, and gasoline tanks are also carried in this space.

The engine room, containing the propelling and auxiliary machinery, is placed aft, together with a portion of the accumulator battery. Surface propulsion is effected by two sets of four-cylinder, vertical, gasoline motors, developing an aggregate of 440 horse-power, while when traveling submerged two electric motors developing an aggregate of 250 horse-power are brought into service. The capacity of the secondary battery is 500 kilowatt hours. Forward of the engine room are the lateral water ballast tanks, and amidships the conning towers in which are placed all the devices for steering, diving, and controlling the boat. The conning tower, built up of light plating has a ship-shaped form, for the purpose of minimizing resistance when the craft is traveling submerged. In the bow are the second section of the electrical accumulators and the torpedo tube room and gear. There are two torpedo tubes carried in the bow, while on the deck, aft, mounted on a bridge, is a third tube.

The diving rudders are mounted in pairs, one on either side, fore and aft, with an ordinary vertical rudder at the stern for lateral steering. Each motor set drives a reversible propeller. The accommodation for the navigating officers is in the conning tower, while the quarters of the crew of ten men are in the bow, as is also the galley.

In the Lake types of the Germania class of submersibles, Diesel engines, using heavy oil in preference to the more volatile and inflammable gasoline, are used. These motors develop from 200 to 220 horse-power. For underwater navigation the usual electric motors are utilized. The heavier oil engines are useful in those seas where the lighter fuel is unobtainable. When gasoline is used, as in some types, the radius of action on the surface at the reduced speed of nine knots is 1,450 miles, while submerged it is 45 miles at the speed of 6.5 knots per hour.

Krupp submersible boat running on the surface.

Special arrangements have been made to secure an adequate ventilation of the interiors of the boats. During surface operations the air is drawn in from outside. When traveling submerged, the heated atmosphere of the engine, and the exhaled air of the crew, is drawn off through ventilators which pass it through various filtering, oxygenating and cooling devices, after which it is returned to the interior. By this means it is possible for the craft to remain under water for twenty-four hours at a time without the crew experiencing any inconvenience or difficulty in breathing. The electric accumulator compartments are hermetically sealed so as to prevent escape of poisonous gases into the interior, and to prevent the spilling of the contents through the rolling and pitching of the boat when diving. Two periscopes are carried, the tubes of which are each 16½ feet in length, which permits the craft to be navigated at a depth where it is secure from the fire of projectiles of an enemy.

Various safety appliances are fitted to prevent the vessel being placed *hors de combat* either by hostile fire or accident. The water ballast tanks can be emptied of water and charged with compressed air very rapidly, there being a reservoir of 121½ cubic feet capacity constantly maintained under high pressure for this purpose. In order to facilitate the salving of the vessel, the outer hull is furnished with a number of shackles, to which the hawsers of the salvaging appliances can be attached for raising the craft.

A telephone wire is also carried whereby communication with the interior of the submarine from the surface can be maintained. The outer end of this line is attached to a buoy which can be released automatically.

The boat awash, with conning tower partially submerged.

Variation of the Size of Drops

When a drop is detached from a capillary orifice, the perimeter of the section of rupture is considerably less than that of the orifice, and the surface tension calculated according to Tate's law is much too small. It is usually assumed that the weight of the drops is independent of their frequency, whereas actually this weight shows a continual variation, which may exceed a quarter of the total weight. The results of the author's measurements show that the weight of the drop is at first sensibly constant and that it begins to increase as soon as the frequency surpasses 15 per minute. The increase is initially rapid, but later proceeds more slowly until at a frequency of 100 the weight passes through a maximum. As the frequency increases continuously, the weight of the drop exhibits three further maxima, each greater than the preceding, and subsequently appears to diminish continuously. It is evident that, when the increased frequency causes the diminution of the volume of the drop to exceed a certain limit, the drop assumes a different form, passage from one form to the other being in general sudden.—P. Vaillant in *Comptes Rendus.*

Artillery for Airship Attack

Special Designs for Guns, Mountings, and Projectiles, to Meet New Conditions

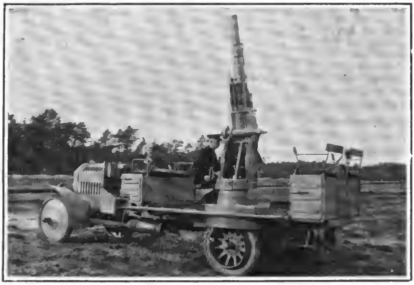
After having studied the problem which is presented by the conditions of firing at objects at great heights and at an angle such as is required for use against airships, aeroplanes, or balloons, the Krupp firm has brought out three general types of cannon, each of which is adapted for a special use. In the first place we have the more simple type of cannon with field mounting, while a second type is constructed with a view of being placed upon a motor car. For use on shipboard they design a third type, illustrated in our engraving. In the second and third cases, the cannon is designed to be rapidly rotated in all directions by the use of a central pivot base such as is usually installed on vessels and for coast defense use. On the other hand, the field gun has its wheels arranged so as to turn upon pivots, which allows of placing the wheels in the crosswise direction in the position here shown. In order to give effective results it is found that the angle of elevation must be at least 70 degrees, and the field gun is designed to reach this angle. The automobile and ship cannon will, however, make a greater angle, the maximum being for these two types as high as 75 degrees. In all these cases a rapid rate of firing is given by an automatic opening and closing of the breech. The caliber has been reduced as much as possible, as also the weight of the projectile, while the long bore gives a high initial speed to the shot and diminishes the time required to attain the mark. Owing to the lessening of the caliber, greater lightness is obtained, and this is a much to be desired advantage, especially in the field and the automobile types of gun.

Sighting is carried out in the most efficient manner by the use of an appropriate form of sighting telescope in combination with a general finder which covers a wider range of field. There is also a range-finder by which the distance is first obtained, and afterward the indications are directly given so as to be able to point the gun for different heights of the airship without loss of time, and thus the use of firing tables is dispensed with in all these cases.

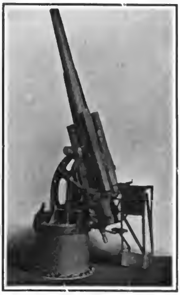
The question of the kind of shot which is best adapted for firing upon balloons or airship is of prime importance; and this matter has been made the object of a number of experiments. It is recognized that shrapnel will penetrate the balloon envelope, but without doing much damage at least of an immediate nature, seeing that the holes are closed again for the most part by the internal pressure of the gas, so that the loss of gas is not a rapid one, and the airship is able to reach a place of safety in the majority of cases. It is found that the most effective form of projectile is a special kind of grenade, which is designed to explode in the interior of the balloon and to bring about ignition of the gas. The new projectile designed by the Krupp firm is intended to accomplish this, and at the same time the path of the projectile from the time it leaves the gun can be followed by the use of a special smoke producer carried on the shot. By observing the trail of smoke the gunner learns whether the shot comes near the mark. When the projectile leaves the gun, the smoke producer has been set working by an appropriate device. At night the path of the shot is still followed by the light which the smoke producer gives out. When it penetrates the envelope a very sensitive device causes the detonation of the grenade.

In the case of the field cannon, which has a 6.5 centimeter bore (2.6 inches), the weight of the gun itself is 775 pounds and that of the chassis 1,150 pounds, making a total of 1,925 pounds for the cannon when prepared for actual service. The gun can be turned about through a complete circle, and has a maximum vertical angle of 70 degrees. The weight of the projectile for this type is 9 pounds. The initial speed of the shot is 2,050 feet per second. With the field gun it is possible to cover a maximum range of 28,550 feet, and a maximum height of 18,800 feet.

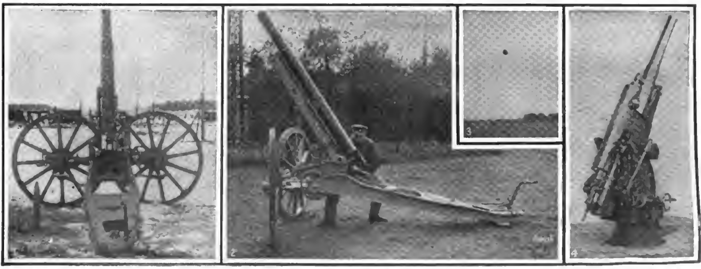
Of a heavier build than the former and also of greater range, is the second type of gun of 7.5 centimeter (3 inch) caliber, which is designed to be mounted upon a heavy motor car, as we represent it in our engraving. Like the former, it is provided with hydraulic recoil brake, and in the present case there is used a middle pivot. For elevating and lowering the gun through the required range there is used a double-toothed sector which is driven by pinion and crank. A special arrangement is used for the rotation, by which a slow movement is obtained, but a quick rotation may also be given by a more rapid mechanism when it is needed to turn the gun rapidly into any desired position. It is to be noted that, owing



The 3-inch 12-pounder Krupp field piece for airship attack. The weapon can be brought to a maximum elevation of 75 degrees. The motor car on which it is mounted is of 50 horse-power and has an average speed of 30 miles an hour.



The 4.2-inch Krupp gun for aeronautic attack, on a naval mount.



1. Nine-pounder gun in battery. It fires a smoking shell. 2. Gun carriage may be swung in complete circle around a pin at end of tail. 3. Flight of shell marked by streak of smoke. 4. Twelve-pounder for ships and fortifications.

to the high speed at which the airships move, such quick movements are one of the features which need to be especially designed in the case of guns for balloon firing. The weight of the gun itself, or 990 pounds, combined with the weight of the support, 1,550 pounds, gives a total weight of 2,540 pounds for this type of gun. We have here the maximum angle which is reached in the Krupp cannon, or 75 degrees. The weight of the projectile is 12 pounds, and the initial speed 2,080 feet per second. The maximum range is about 30,000 feet, and the greatest height about 20,000 feet. As regards the automobile car which is designed to take the present cannon, its total weight (exclusive of the gun) is 3½ tons, and it has an average speed of 30 miles an hour.

Owing to the fact that both axles are driving axles, with the use of 50 horse-power motor the automobile car is able to travel over very difficult ground, and it easily mounts very steep grades. Under the front seat is a roomy chest which holds a good supply of tools and extra fittings, and special attention has been given to this point so that the car will not easily become disabled. To make the platform of the car as steady as possible during the firing, the platform is clamped tight against the axles. The third type of cannon is of a much heavier build than the two which precede, seeing that in this case it is designed to be mounted on shipboard, and hence the weight does not need to be reduced as in the other cases. It is of a considerably larger caliber, this being 10.5 centimeters (4.2 inches). In most of the details it is designed on the same lines as the second type. It is intended to be mounted generally upon torpedo boats or swift cruisers and naturally the gun can be brought into service as an ordinary cannon in cases where it is needed. For the gun proper, the weight is 3,080 pounds, while the support weighs 3,520 pounds, giving a total weight of 6,600 pounds for this type. Like the former, the angle of elevation is 75 degrees at a maximum. The projectile, weighing 40 pounds, has an initial speed of 2,300 feet per second. A horizontal range of 44,500 feet is reached, and we have the unusual height of 37,620 feet.

The present types of gun have been given a series of tests by firing upon captive balloons, and while the practice on these may be considered fairly satisfactory, it cannot be considered as anything more than experimental, and the results are only applicable to the particular conditions of the experiment.

In actual warfare the captive balloon would seldom require consideration, and the real value of these new classes of ordinance lies in their effectiveness against big airships provided with guns and bombs and the fast aeroplanes of the scout or bomb-dropper, and for this work results with the new guns are yet to be shown.

Exploding Mines by Wireless Telegraphy

By Dr. Charles Forbes, Columbia University, N. Y.

THE newspaper accounts that have appeared from time to time in regard to the explosion of submarine mines by means of radio-telegraphy might lead the ordinary reader to believe there is danger of exploding powder magazines on war vessels, and torpedoes and mines located in harbors for defense, in the daily use of the wireless telegraph. Such an event cannot, however, take place without the intervention of apparatus specially constructed for the purpose.

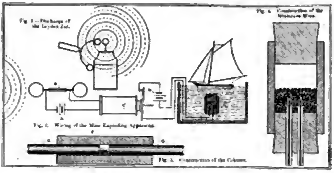


Fig. 1.—Discharge of the Leyden Jar.
Fig. 2. Wiring of the Mine Exploding Apparatus.
Fig. 3. Construction of the Coherer.
Fig. 4. Construction of the Miniature Mine.
A
B
C
D
F
G
G

Experimental apparatus used to illustrate the exploding of a submarine mine by wireless telegraphy.

An interesting laboratory experiment illustrative of the subject may be performed as follows: There must be apparatus for generating the electric waves, known as the Hertzian, from their discoverer; also apparatus for receiving the impressions produced by them. Like the telegraph and telephone the transmitting and the receiving instruments are essential. For the laboratory experiment the transmitting apparatus may consist of the usual amateur outfit. In the absence of this the sparks from an influence electrical machine, the induction coil or the Leyden jar will be sufficient to set up the Hertzian waves. In the simplest form the Leyden jar answers the purpose very well. The receiving apparatus consists of the Branly coherer, which is placed in series with a suitable electric battery, two dry cells being sufficient, and a relay, which in action closes a second electric circuit generated by another battery of two dry cells. This current is conducted by communicating wires to the exploding fuse in the mine to be exploded.

Inspection of the illustration will show the wiring and the arrangement of the apparatus for the laboratory experiment. Fig. 1 represents the Leyden jar being discharged by the discharging rods. Electric waves are represented passing outward in all directions ready to impinge upon receiving apparatus situated in their path. Fig. 2 represents the receiving apparatus. The coherer is at *A*, the battery at *B*, the relay at *C*, the relay battery at *D*, and the mine to be exploded at *E*, resting in a tank of water.

On discharging the Leyden jar, this is what takes place: The electric waves thereby generated pass onward through space, and acting on the coherer, its battery is set in operation, thereby closing the relay circuit, which in turn actuates the fuse, when the explosion of the mine is effected.

The essential part of the receiving apparatus is the coherer. The details of its construction are represented in Fig. 3. A glass tube about 2 inches in length is represented at *F*. Into this there are fitted, rather snugly, brass or copper rods *G*; the internal ends being separated about one eighth of an inch and the external ends having metal disks attached, somewhat larger than those represented in Fig. 2. The space between the internal ends of the rods is to be nearly filled with filings of nickel about 9 parts and silver 1 part. If the pure metals are not available for the filings nickel and silver coins may be substituted. A trace of mercury, which is desirable, may be secured by amalgamating the internal ends of the rods in the glass tube. The coherer has this peculiar property; the filings, in the inactive condition, offer a high resistance to the passage of a battery current of electricity; when acted upon by the electric waves they are said to cohere, offering much less resistance, thereby allowing a much greater electric current to pass. This is sufficient to actuate the relay.

The miniature mine to be exploded is represented in Fig. 4, about the actual size. It consists of a metal tube with a rubber stopper inserted at its upper end and another at the lower end. Through the lower stopper the insulated conducting wires from the relay battery pass. The terminals are connected by a fine iron or platinum wire, which is imbedded in the gun powder in the inclosed chamber. The fine wire on becoming incandescent ignites the powder and the explosion takes place. Interest will be added to the experiment if, preceding the explosion of the miniature mine, the closure of the relay current be made to ring an electric door bell, and if by tapping the coherer, the ringing may be discontinued. In a similar manner electric lights may be lighted on substituting the electric light current for the relay battery current. In actual practice the sending apparatus of the wireless telegraph would be used to set the ether waves in motion and the submarine mine would be attached directly or indirectly to the receiving apparatus. From the above described experiment, it is quite evident that the accidental explosion of mines and other magazines of explosives by means of the Hertzian waves is very improbable. An explosion by electrical induction would be a very different thing, and could only take place at a distance of a few feet. For its occurrence, specially arranged apparatus would also be necessary.

The Other Side of War

By this caption Dr. E. Helme, writing in *Le Temps*, means to indicate the rougher side with which those individuals come into painful contact who feel within their own skins the effects of modern weapons. To the question: Will war be more murderous in the future? this expert answers with an unhesitating affirmative. Wars, it is true, instead of lasting a hundred, thirty, or seven years, as in bygone days, now last only a few months. But this, he says, simply means that the blows are heavier, and the combatants are sooner exhausted. The Russo-Japanese war lasted only eighteen months, but the battle of Sha Ho, in Manchuria, consumed twelve days. Thus, although the number of killed and wounded per day in the actual fighting of the Franco-German war may have been greater, the losses in battle in the Manchurian campaign were much greater in the aggregate. The truly terrible fact, however, is the increasing proportion of mortal to non-mortal wounds: in the Franco-German war of 1870-71, the victorious army lost ten men killed to every 58 wounded; in 1904-05 there were ten Japanese killed to every 37 wounded.

Coming to the explanation of these facts, Dr. Helme dismisses as "a troublesome legend" the story that modern bullets, being smaller and moving more rapidly, inflict less serious wounds. Really slight wounds, he maintains, heal more quickly and more thoroughly nowadays than formerly; but the severe wounds are no less severe and much more frequent. To illustrate this the writer considers, first, the form and structure of projectiles and then their motions. "The lance *well handled* inflicts severe abdominal wounds," and the Japanese cut-and-thrust bayonet "is terrible"; but the writer's main theme is the effect of projectiles.

First comes the rifle bullet, "but yesterday the Queen Murderess of Battles." The German bullet consists of a core of lead hardened with antimony, covered with a steel jacket. It is none the less efficacious because the jacket often comes off and acts on its own account as a jagged fragment of metal, lacerating the human body. The French bullet, though not jacketed, is no kinder to the enemy. It is longer and sharper-pointed than the German, and is made of a mixture of copper and zinc. Becoming bent by ricochetting, it sometimes enters its victim's body in the shape of a hook; sometimes it "tumbles" in its flight, enters broadside-on, and makes a long, gaping wound. Up to a range of 800 meters these rival horrors are one as bad as the other.

The gravity of the wounds depends on a multitude of conditions. On the rocks of San Juan, where the bullets ricochetted in wonderful fashion, the American surgeons reported frightful injuries. It was the same at Spion Kop, in the Transvaal. It used to be said, optimistically, that a bullet heated by friction in the barrel of the rifle would reach its object asepticized by friction; but this hope has been dispelled by the researches of von Koler, showing that the temperature of the projectile never comes within many degrees of that which is necessary for the destruction of microbes. The cruelty of the modern bullet has been augmented, too, with the increase of its rotation, so that it acts not only as a club, striking a heavy blow, and a perforating point, but also as a gimlet which lacerates the tissues.

But bullets, after all, are mild agents of destruction when compared with up-to-date shells. The shell wounds in the war of 1870 were only 91 per thousand; in the Manchurian campaign they were 176 per thousand; in the Balkan war of 1912 they were four times as numerous as in 1870. The shrapnel shell has the advantage (to its employer) of scattering destruction by means of some hundreds of small round bullets as well as the fragments of the shell itself. This "devil's watering-pot," as the Russian soldiers called it, works best within a radius of 10 to 30 meters; at 100 meters its "dewdrops" are still lively enough to penetrate 6 centimeters of pine board; at 300 meters a turban will protect the head from their efforts. The tortuous incisions made by shrapnel are particularly difficult to disinfect. But in spite of all this, and though the ear of the most hardened veteran is said never to become accustomed to the death-song of shrapnel overhead, the common shell is really more terrible. Its fragments, brought to a very high temperature by the explosion, "burn the flesh so as to compel cries of agony which only morphine can quiet." Lastly, the large shells of the naval guns "not only cut like razors, but asphyxiate, amputate portions of the body and crush."

Dr. Helme's study of the movement of projectiles and its effects at various ranges, and on various tissues, should be minutely interesting to those who love "the pomp and circumstance of glorious war." Its effects on bones, in particular, are classified as: (1) explosive; (2) comminutive; (3) contusive. The first, resulting when the range is not greater than 500 meters, splinters the bone so thoroughly as to explain the frequent accusations of using explosive bullets which have become a feature of modern war news. The second, proper to the zone of from 500 to 1,200 meters, is distinguished by the danger of bringing with it fragments of soiled clothing, carrying gangrene. These effects are observed only in the main body of the bone; in the spongy extremities there is less harm done except when the extravasation of blood brings on a diseased condition of the joint.

The effects of projectiles on soft tissues and organs containing liquids has led students of the subject to some highly interesting experiments. A bullet fired at an empty metal vessel makes a small hole both entering and leaving. But a bullet fired at the same kind of vessel filled with water, while it enters through a small hole, as before, leaves through a jagged opening 12 centimeters wide. This very fairly illustrates the effects of a bullet upon, say, a human stomach. The explanation advanced by the experimenter is: "In its passage, the bullet carries with it molecules, which are of very small mass, but move with great rapidity; these, being projected in all directions, have the effect of compressing the inert molecules (of the surrounding medium) and an outburst of the wall of the vessel follows at the egress of the projectile." And so it is that bullet wounds in the stomach, bladder, liver, intestines and head, received at short range, produce veritable explosions of these parts.

The writer concludes his discussion with the consolation, such as it is, that science and humanity appear in a much better light when we consider their achievements for the benefit of the good men who are wounded in their country's service.

Using an Economizer on a Hot-Water Heating System

By W. L. Durand

The use of an economizer for heating water for a forced hot-water system is sufficiently novel to warrant a brief description of a recent installation of this character.

The original heating system was installed several years ago, and a live-steam heater and a 150 horse-power water-tube heating boiler were used for heating the water. Because of rapidly increasing demand on the heating system, as new buildings were added, the boiler and heater were of insufficient capacity. Furthermore, the space where the boiler was located was required for a steam boiler to take care of the increased load on the engines.

The power plant consists of 1,600 horse-power in water-tube boilers and an engine-low-pressure turbine plant. It was found that greater yearly economy was obtained by using the exhaust from the engines in a low-pressure condensing turbine than for heating the water for the heating system.

After examining several different plans, the final selection was made on the basis of the minimum total annual expense, although the first cost was the highest. The system has now been in satisfactory operation for the greater part of the present heating season. The leading features are as follows:

The 150 horse-power heating boiler was scrapped to make room for a new steam boiler, and heating apparatus was installed, partly in the form of an economizer and partly as a heating boiler, and sufficient altogether to provide for 65,000 square feet of radiation, which allows for all possible future expansion on the present property.

The flue gases left the boilers at from 500 to 600 deg. Fahr. An economizer was installed to utilize the available heat, which was estimated to furnish about one third of the total required for the system under maximum weather conditions. On this basis, moreover, the same estimate indicates a capacity sufficient to provide for 50 to 60 per cent of the total average heat required throughout the heating season. These estimates indicate the economy which the use of the economizer may be expected to secure.

The economizer consists of forty-four sections, each section 10 tubes wide and each tube 12 feet long, making a total of 7,200 square feet of heating surface. The branch pipes were increased from 4 to 10 inches to accommodate the large volume of water that is to be handled. One 2½-inch safety valve was placed on each end of the economizer. It was found impossible to locate the economizer in the power house, and it was, therefore, placed outside on structural-steel supports, as shown in the accompanying illustration. A house, of angle-iron frame and corrugated galvanized-iron covering, was built over the economizer to protect it from the weather. The roof is made in removable sections to permit of drawing tubes.

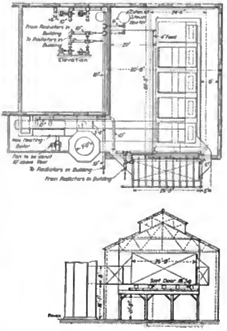
To provide the balance of the heating capacity, as required, a standard 285 horse-power water-tube boiler, with longitudinal drum, was installed, so that in case it should ever be desired for power purposes, no changes would be necessary. The only special feature is a baffle-plate in the center, so arranged as to prevent the water from short-circuiting through the drum. This baffle-plate is made in sections and can be taken down and removed through the manhole if the boiler is to be used for power purposes. The water enters the rear of the drum and flows down the rear header, up through the tubes, up the front header, and out at the front of the drum. Therefore, the flow of the water is in the same direction as the natural circulation in the boiler under steaming conditions.

Both economizer and boiler are provided with bypass connections, so either can be run without the other.

The dampers in the main smoke breeching and in the intake to the economizer are controlled by a thermostat located in the hot-water pipe leaving the economizer.

On account of the long run from the boiler to the main breeching, a balanced-draft system was installed to prevent the gases being blown out of the furnace door. The fan used is a centrifugal blower of the multi-vane type and is controlled by a thermostat located in the flow pipe leaving the boiler. By the use of the two thermostats any desired temperature is maintained in the circulating water.

The water is circulated by a double-suction, 1,500-gallon per minute centrifugal pump, directly connected to a motor. The present pump is kept in reserve for use in case of emergency. An interesting point may be mentioned in connection with the circulation of the water. Two methods of pumping have been tried with the system. First, pumping the water through the boiler and economizer or heater and then to the heating system. Second, connecting the suction side of the pump to the boiler and economizer and pumping direct to the heating system. It was found after trial that much better results were obtained with the latter method, which is the one now in use.



Plan and elevation showing arrangement of heating system.

An added economy is gained in the use of the economizer by connecting it to the boiler-feed line so that during the summer when the economizer is not used for the heating system it can be used to heat the feed water. The feed water now enters the boiler at about 200 degrees; if it passes through the economizer it is raised to between 280 and 290 deg. Fahr.

In operating an installation of this kind, care should be taken to always keep the pump going. If the economizer is to be cut out or the pump stopped, the dampers to the economizer should be fully closed, and if possible the economizer emptied of water. If this is done no danger from an explosion need be feared.

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* Reproduced from *Power*.

Waste in the Brass Industry*

In 1909, according to the Thirteenth Census,[1] 1,021 establishments making brass and bronze products spent for materials $99,228,000. If it be assumed that 80 per cent of that amount was for metal, $80,000,000 is spent annually for raw metals in such establishments, which do not comprise a third of the whole number of firms that melt brass and bronze.

No attempt was made to procure data on the tonnage melted, but ten firms—manufacturers of commodities listed under other headings in the census reports—did give such data, the total being 58,000,000 pounds for the ten firms, some of which are not exceptionally large. If a ratio of melt to metal bought of 2 to 1 be allowed, the figures quoted mean that 29,000,000 pounds of metal was bought at a value of about $4,000,000. In view of the known size of other firms, not included in the census classification under manufacturers of brass and bronze products, but furnishing replies to inquiries, a conservative estimate of the value of the metal bought by such firms would be about six times that bought by the ten firms mentioned, or, say, $24,000,000, which, with the $80,000,000 for those that are included, makes $104,000,000 spent for metal by the firms included in the census statistics and by those furnishing replies. As many other firms melting brass and bronze do not fall into either of these classes, it appears that the estimated value of all the metal used should be at least $120,000,000.

The consumption of copper in the United States in 1911 was about 680,000,000 pounds.[2] If two thirds of this total, or 450,000,000 pounds, be considered as having been used for making brass and bronze, and if the average copper content of the alloys used be assumed as 80 per cent, the deduction would be that about 560,000,000 pounds of brass and bronze products was made from new copper. It seems conservative to estimate that at least two thirds of the copper consumed in the country is in the form of brass and bronze, as Lathrop[3] states that one corporation making mainly wrought yellow brass uses in its various plants approximately a third of all the copper consumed in the United States. To this must be added the old metal used. Half as much old scrap or alloyed ingot as new metal, that is, 280,000,000 pounds,[4] seems a fair estimate, so that 840,000,000 pounds should represent the total metal bought. The average value of brass and bronze being taken at 15 cents a pound, by this method of figuring $126,000,000 would be the value of the metal passing through the brass and bronze furnaces of the United States in a year. For purposes of computation the estimate of $120,000,000 has been taken.

A 2½ per cent melting loss, equivalent to a loss of 5 per cent on the metal bought, thus means $3,000,000 a year lost in metal alone. Could this be reduced to the 2½ per cent loss (equivalent to 1¼ per cent on the melt) shown by good practice, a saving of $1,500,000 a year would result. If the fuel consumption and crucible life were brought from the average practice up to good practice, and if furnaces that cut down or eliminate crucible cost and allow greater production with less labor cost were used wherever practicable, a saving of at least another half million would be made, or a total of $2,000,000 a year that the non-ferrous-alloy industry of the United States might save merely by bringing average furnace practice up to the standard of the best practice.

However it be figured, it is certain that the statement that the problem of the wastes in brass melting is one of the greatest importance in the waste of alloy manufacture[5] is correct.

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* From "Blast Furnace Practice in the United States," by H. W. Gillett. Bulletin 73, Bureau of Mines, U. S. Geological Survey.

[1] Thirteenth Census, Advance Bulletin, "Statistics of Manufacturers," 1910, p. 75.

[2] "Mineral Industry," 1911, p. 165.

[3] Lathrop, W. S., "The Brass Industry of Connecticut," 1909, p. 127.

[4] U. S. Geological Survey Press Bulletin 117, "The Country's Enormous Junk Heap," June, 1913, p. 2. The recovery of secondary copper by smelters and refiners in 1912 is here given as 137,507 tons. This figure is on copper and the copper content of the recovered brass. That for remelted brass (alloyed ingot) is 101,437 tons, or nearly 203,000,000 pounds. Besides this, in foundries themselves there is a large remelt of old scrap, which does not reach the refiner. See also *Foundry*, vol. 41, 1913, p. 384.

[5] Parsons, C. L., "Notes on Mineral Wastes," Bulletin 47, Bureau of Mines, 1912, p. 20.

Modern Turret Fortifications

New Construction to Oppose Increasing Power of Guns

THE history of fortification is as old as that of nations. New requirements, born of the incessant improvement of artillery, have modified its details, but its object remains the same as always: to allow the defender of a post to hold out against superior forces. For this purpose it is necessary to create an effective obstacle to the approach of the enemy, and also to provide shelters in which the defenders may be protected from the fire of the enemy, while remaining free to use their own guns effectively.

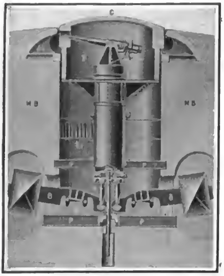


Fig. 7.—Section of Galopin disappearing turret.

C, armored roof and hood; AC, armored rim; T, firing chamber; MB, concrete; BI, operating room; B, arms of counterweights; R, rollers; P, iron beams.

Vauban inclosed a wide and deep ditch between two thick walls, the escarpment on the inner side and the counterscarp on the side toward the enemy, and we find these elements repeated in all the old forts, including those which were built in the reconstruction of the French system of defense after the war of 1870. The forts surrounding Paris are classical examples of this construction.

The New Principles of Fortifications.—The newest forts present a totally different appearance. The ditch remains, but the huge earthworks of the old forts, 30 or more feet in height, have been abandoned as too vulnerable under the very accurate fire of modern artillery. In the most important French forts these great earthworks have been replaced by much lower but much thicker parapets, which are just high enough to give the defenders a good view of the surrounding country. The experience of the fort of Malmaison in 1886, following the introduction of highly charged torpedoes, proved that a thickness of at least 40 feet of earth is required to give certain protection against these terrible engines of destruction. Parapets of 45 or 50 feet in thickness are found in many of the newest forts. The ditch is constructed on a new plan. On the side toward the enemy, a counterscarp about 15 feet high is retained, but this is now constructed of cement concrete and is at least 6 feet broad at the top. By this construction the joints of ordinary masonry are eliminated, and the wall forms a homogeneous mass of remarkable strength. It is reinforced by a mass of broken stone, 10 feet thick, placed in front of it, which constitutes an obstacle to undermining by shells striking in front of the concrete wall and bursting underground. The escarpment on the inside of the ditch has entirely disappeared, in its original form at least. Now the bank is allowed to have its natural slope from the firing line to the bottom of the ditch, and a strong grille of barbed wire imbedded in concrete replaces the stone wall of the old type, which is too easily destroyed by persistent artillery fire. Finally, as the defender cannot see the bottom of the ditch from the top of the parapet, chambers of concrete with very thick walls, known as flanking coffers, are constructed at each end of the counterscarp. From these coffers the ditch can be raked by the fire of machine guns and other rapid-fire guns, driving away any enemy rash enough and skilful enough to enter the ditch. At present, more than ever before, it is imperatively necessary to protect the defenders of the fort against bombardment, which now may be extremely effective. For this purpose, shelters are constructed beneath the parapet, with concrete walls 8 feet thick, and in these shelters the troops detailed for service on the rampart take refuge during the entire fire of the enemy. The remainder of the garrison is sheltered in barracks, also built of concrete and furnished with all the indispensable conveniences of daily life. All of these rooms, including the flanking coffers, the shelters on the ramparts, the barracks, the casemates, and the turrets described below, are connected by a system of underground passages, through which the members of the garrison can circulate freely without being exposed to the fire of the enemy. Only a few sentinels keep watch on the ramparts, from armored lookout towers, for the purpose of giving warning of the enemy's approach.

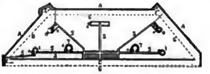


Fig. 1.—Plan of a modern fort.

A, counterscarp of concrete 8 feet thick; G, barbed grille forming escarpment; 1', barracks; F, flanking coffers; S S, underground passages; T t, gun turrets; a, fighting shelter.

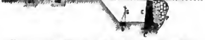


Fig. 2.—Section of a parapet and ditch of a modern fort.

A, fighting shelter; P, broken stone; G, escarpment grille; b, concrete; C, counterscarp.

Gun Turrets.—The precision of modern gun fire makes useless all unprotected pieces of artillery, which would naturally be the chief points of attack by the enemy. Hence the large guns, which were formerly placed in the forts, are now collected in batteries behind the line of forts, and the latter contain only very small numbers of guns, devised for special purposes. It is necessary for a fort to be able to constitute its own defense, and to protect to the last moment the guns which command an important point. These guns might be mounted in casemates of concrete with walls 8 feet thick, which would afford effective protection against the enemy's fire. The openings through which the guns would be fired must in this case be made extremely narrow, in order to avoid making them particularly vulnerable, but guns protected in this way could be fired only in a very small number of directions. The adoption of the revolving armored turret is a much more satisfactory although more costly solution of the problem. A gun turret consists essentially of a cylinder made of armor plates, revolving in a well lined with concrete, which contains the necessary machinery and magazines in addition to the guns and the gunners. The concrete walls which line the shaft vary in thickness from 10 to 16 feet, according to the type of turret, and are protected, on the side toward the enemy, by a mass of broken stone and an earthwork at least 30 feet thick. In order to obviate the possibility of a shell striking the edge of the well and detaching fragments of concrete, which might fall between the wall and the turret and prevent the rotation of the latter, the mouth of the well is formed of a ring of hard cast iron, which affords additional protection, and which furthermore provides a way of communication around the turret. At first, a simple rotating turret was employed (Fig. 3). It consisted of an arched roof of hard cast iron, 16 inches thick, supported by a frame of steel plates about 1½ inches thick. The roof alone appeared above the massive concrete wall of the well. Hence a turret, carrying two 6-inch guns, offered a target only 3½ feet high and about 18 feet wide. The turret was turned by hand, by means of

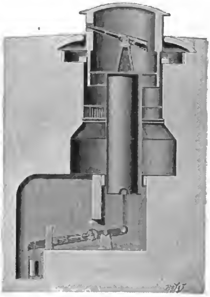


Fig. 8.—Section of 3-inch disappearing turret in firing position.

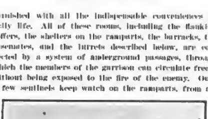


Fig. 3.—Earliest type of revolving turret.

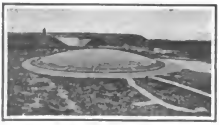


Fig. 5.—Turret in disappearing position.

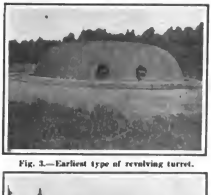


Fig. 4.—Second type of turret with guns protruding.

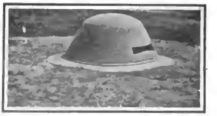


Fig. 6.—Conning tower.

gearing, the movement being facilitated by raising the whole mass, by means of a hydraulic press acting upon the pivot of the turret, so that only 1/10 of the weight rested upon the wheels on which it turned, and the remainder was supported by the cylinder of the press. The increase in the use of armor and the continual improvement in artillery led to the construction of the second type of turret (Fig. 4), which is made of laminated iron and is much less visible. This was soon superseded by the disappearing turret (Figs. 5, 7, and 8), which is the only type now employed. In this turret the guns are retracted entirely within the armored portion. The portholes, which were very visible in the earlier turrets, are entirely covered, and they emerge from the concrete well only during the time required for firing.

The disappearing turret is constructed for one or two 6-inch guns, two 3-inch rapid fire guns or two machine guns. The type, however, does not vary essentially. The moving mass is counterbalanced by weights, as in the turret already described, but the improvements introduced into this system of counterbalancing by Galopin have made the turret for two guns the remarkably effective weapon which is now installed in our forts. The fulcrums of the counterweights move on rocker bearings, so that the length of the lever arm varies during the motion in such a manner that the turret reaches its final position with zero velocity. The turret being in its position of eclipse, and offering only its low roof as a target to the enemy's fire, the guns are loaded, and are aimed by the indirect method, by means of drawn plans. Meanwhile the counterweight has been wound up, and when all is ready, at the word of command, a catch is released and the turret rises. At the top of its course, the two guns are discharged automatically by the closure of an electric circuit, and the turret immediately sinks. The time which elapses between the word of command and the complete disappearance of the turret is only five seconds, and two shots can be fired every 90 seconds.

The 3-inch gun turrets operate in a similar manner. The machine-gun turrets are somewhat different. As they are much lighter, they can be moved directly by the gunners, and so easily that they can be caused to sweep the whole crest of the glacis during the volley.

The thickness of the walls varies with the type of turret. For the large calibers it is about 12 inches, a thickness which offers an effective defense against modern siege guns. In 1886 the Roumanian government, desirous of equipping its forts with armored turrets, made a very elaborate series of experiments with a French and a German turret. Neither turret was at all injured by either the explosive or the armor-piercing projectiles of that day. Since that time the precision of fire has greatly increased, but the force of projectiles has undergone less change, so that it is probable that these turrets would still withstand a siege without serious damage. Experiments are now being made with an 11-inch mortar, throwing a shell weighing 550 pounds. The nearly vertical fire of these mortars would certainly be very dangerous for the roofs of disappearing turrets, but it should be remembered that in the Roumanian experiments 164 shells were discharged from a German rifled mortar of 8 inches caliber, at a distance of less than 3,000 yards, without making a single hit. The French disappearing turrets are constructed in accordance with the results of experiments made in 1887, 1905, and 1906. In regard to their strength, they inspire perfect confidence, and as their fire is very accurate, they constitute excellent weapons. Unfortunately, they are very costly, like all modern fortifications.—*La Nature.*

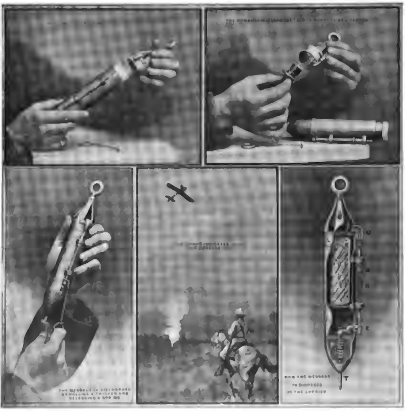
Throwing Military Messages from Aeroplanes

As the flying machine developed, the need of subsidiary apparatus became apparent. Military men soon demanded the installation of wireless apparatus, guns, armor and similar accessories. While a great deal of experimenting has been done to give them what they want, it can hardly be said that a very great measure of success has as yet been attained. Especially is this true of the wireless equipment. The sending apparatus which can be carried on an aeroplane is necessarily of very small range, and the receiving apparatus must struggle with the difficulty of interference. Some day these objections will undoubtedly be overcome, but until they are, a French inventor and aviator, Paul Fugairon, believes that some such apparatus as he has invented and tested near Brest will be most acceptable to military men. With his invention a message can be dropped in full flight by an aviator who is sufficiently near his destination, the craft returning immediately at full speed to the enemy's position. There is no danger that the message will be blown away by the wind, or that it will be lost or damaged in mud, dust, high grass, and heavy foliage.

As the accompanying diagram shows, the apparatus consists of a hollow cylinder, in which the message is received. At its base the cylinder is inclosed by an ogival member *P* into which lead has been poured, so that the apparatus will always drop upon the point *T*, which passes freely through the lead. At the other end of the cylinder is a cover *L*, the top of which is formed like a lantern with four open windows *C*. Within the cover are four clamps to hold material for a Bengal fire. This is ignited by the explosion of a cap of mercury fulminate. As the apparatus strikes the ground, the cap is exploded by the firing pin *B*, which is guided in two brackets, and the flame of the explosion being conducted to the Bengal-fire material through the curved tube *C*. A lever mechanism here connects the firing pin *B* with the point *T* the lever mechanism being held in a position of rest by the spring *R*. As soon as the point *T* penetrates the ground the spring *R* is compressed, the lever mechanism is operated to pull the pin *B* backward a short distance, and to release it immediately afterward. The firing spring, which was put under tension before the message was dropped, is thus liberated, so that the pin *B* is forced against the fulminate cap.

The exceedingly bright Bengal fire which flashes up can be seen not only at night, but in daytime as well. What is more, it burns long enough to allow a soldier who has been watching for it to cover a distance of 300 yards to the spot where it has fallen, and whither its light guides him.

Obviously not only written messages, but also sketches and rough maps, can be "canned" in this way.



By means of this simple device messages can be discharged from an aeroplane with the certainty that they will be found. As soon as the device strikes the ground Bengal fire is ignited, and the resultant smoke indicates where the message is to be looked for.

Limitations of the Submarine

A CORRESPONDENT in *The Engineer* discusses this now important question in a comprehensive way, and comes to the apparently logical conclusion that the powers of the submarine have been overestimated by the lay public.

"There is great danger of losing one's sense of proportion amid the welter of statements recently made regarding the value of the submarine as a naval unit in time of war. That this type of vessel is a serious factor, and one to be given a prominent place in any balancing of naval forces is not to be denied; and that it is a rapidly developing arm is unquestionable. The potentiality that it possesses for becoming a more serious factor still in the near future is an unknown quantity, but there seems little doubt that the type will increase in size, power, speed, and offensive capacity. It must be noted, however, that it has definite limitations in action, which are imposed upon it by reason of the very qualities it possesses as an attacking force. It attains comparatively slow movement even on the surface, is very slow when submerged, and, above all, is exceedingly vulnerable. To assert that the submarine will drive the battleship off the seas is to follow our neighbors of France in a misconception of relative values, which has placed them in an unenviable position with regard to the larger units, an error which recent naval policy in that country is designed to retrieve. It is quite true that the submarine in its present state of development, and in its future possibilities, is a serious menace to the battleship, unless necessary precautions be taken, but so is a lightly armed body of sharpshooters a menace to an army on the march; the idea that the one can ever take the place of the other, however, is inconceivable. It can neither move quickly, nor inflict heavy blows, such as big guns are capable of delivering; it could not provide efficient convoy for trade routes, nor be fully effective in heavy weather at sea. The functions of the submarine approximate more nearly to those of guerrilla warfare than to those of open battle. The vessel is designed to deliver powerful blows by means of insidious and unsuspected torpedo attack, and for this reason might be exceedingly useful in preventing effective blockade or in attacking hostile ships when in harbor; on the high seas it is a different matter. What, then, are the conditions which limit the scope of its effectiveness?

"It may be assumed that the general design of these vessels has become more or less fixed; when on the surface they differ very little in appearance from an ordinary destroyer, at the forward end especially, and can therefore keep the sea in moderately heavy weather; but even the largest of them, say up to 200 feet in length, have a maximum speed on the surface, and in calm weather of only about 17 knots, and when submerged 10 knots. It will be seen, then, that even for such a large submarine to approach a battleship on the alert against attack is no easy matter; the surface speed of 17 knots can only be used to bring the vessel into the approximate vicinity of her foe; she dare not make her approach known by showing herself on the surface; it is necessary for her to dive and to continue the attack at the more moderate speed of 10 knots until coming within the effective striking distance of the torpedo. The range of modern torpedoes is very great, and the practice made with them under peace conditions is very accurate, but it would probably be a different thing to make certain of a hit under war conditions when it may be supposed that the quarry would be kept on the move, possibly varying both speed and direction in order to confuse the aim of her opponent, for it cannot be assumed that any commander of a battleship would be quiescent and allow an easy attack to be made on his ship if he were in a region where such an attack was to be feared. The submarine must therefore approach to within a reasonable distance, and to do this must come to the surface periodically in order to use her periscopes, taking the risk of escaping observation. If she is successful in this and can discharge two or more of her forward torpedoes there is still a great chance of missing her mark, for the progression of a submarine is not a perfectly regular thing when she is submerged. The depth of submersion is regulated by the diving rudders, and as a submerged body is very easily diverted in the vertical direction, a small force is sufficient to cause change of inclination of the boat, with the result that the vessel's course is a more or less sinuous one, even in calm weather. The successful finding of an erratically moving battleship by a torpedo delivered by a submarine which is also moving somewhat erratically is not the easy proposition that it may appear to be on paper. It may be assumed that the submarine will accept any risk in order to deliver a successful blow on an opponent, which represents such an immense value to the enemy, but, with all the goodwill in the world and the most devoted endeavor, it may prove a task impossible of accomplishment unless a combined attack be made by more than one boat.

"The commander of a submarine has many things to watch before he can discharge his torpedo with any probability of success. His own vessel must be navigated in a double sense, that is, both horizontally and vertically, with the added difficulty that the vertical movement is very sensitive to small differences of vertical force. He must watch his enemy and judge accurately both her course and speed; he must also keep an eye on the horizon for possible foes other than the one to which his attention is mainly devoted; and all this must be done by means of periodic peeps of a few seconds' duration from the telescopic periscopes. It is well known that very few of the torpedoes which were discharged by destroyers in the Russo-Japanese war ever found their mark, and it is not likely that the submarine would be more successful than the destroyer in this respect unless it be found to be more possible than appears probable, to make a comparatively close approach to the ever vigilant mark before discharging the weapon.

"Safety of the large vessel would seem to be centered in her power of keeping a speed greater than that of the submerged vessel, and in continually changing course, so that it shall be made necessary for the submarine to expose her periscope at intervals, for that is the only means of locating her position unless the aid of seaplanes be invoked. Lack of submerged speed is therefore a most pronounced limitation of the submarine, and one that cannot easily be remedied. The cells which supply current to the motor which drives the ship when submerged must be of sufficient capacity to give her a large radius of action, or she may be obliged to come to the surface, and thus fall an easy prey to her enemies. If the battery runs out, the vessel must either come up or adopt the dangerous alternative of filling her tanks and lying on the bottom until the danger has passed; this, it is needless to say, is a last resort, which could only be carried out in comparatively shallow water. There is necessarily a much greater risk in submarines from errors of navigation than in ordinary vessels, and this risk in the heat of action would probably be accentuated. Whether this is a serious item or not it is impossible to decide in absence of actual war experience; present-day design provides much greater longitudinal stability than was possessed by the earlier types, and erratic diving is not now so likely to occur, but the personal element is always present, and it is this element which is liable to variation in times of stress and excitement. The third limitation is vulnerability. Submarines are naturally liable to fatal damage with little injury to the fabric of the hull; when in the submerged condition a very small quantity of water is sufficient to change trim and reduce the reserve of buoyancy. This limitation is a very obvious one, and is inherent in the design. A considerable amount of intruded water can be easily dealt with by the pumps and compressed air plant, and there is generally as a last resort the provision of a heavy keel which can be dropped in emergency, so enabling a damaged submarine to be brought to the surface; but these qualities may become practically useless in time of war, for as soon as the boat appears above water she falls an easy prey to her surface foes. Looked at broadly, this danger to the submarine does not count for much. Sacrifice of the whole vessel would be amply justified at the price of sinking or even disabling a much larger unit, but the moral effect of these possibilities of disaster must count for something to the crew, however brave they may be, and may affect to some extent the conduct of their operations.

"These vessels are really naval guerrillas, and must be tackled in the same manner as similar foes on land; they must be attacked and prevented from harassing large vessels by what may be called torpedo sniping. The battleship is too valuable a unit to be risked on such work; smaller classes of ships are better fitted to scour the sea with the aid of seaplanes as scouts, and to make the task of submarines an exceedingly difficult one. If battleships be threatened, in spite of the protecting screen drawn round them, they still have their great advantage of speed and mobility further to increase the difficulty the submarine has in placing a successful blow. The great mistake would be to ignore the changed conditions brought about by the advent of the submarine as a force to be seriously reckoned with and to fail in making adequate provision to cope with the danger.

"It may be presumed that naval authorities all over the world are fully alive to the position, and will not allow themselves to be unduly swayed by those who, lacking a proper sense of proportion and of relative values, see the end of all things in the growth of the new arm, and make the unwarranted assumption that the battleship is doomed, whereas all that has happened is a new method of attack has to be met by other methods of defense than those which have hitherto been necessary; and that the provision of submarines must be proportionately large to match those of possible foes."

Age of Production in Invention and Other Fields

Genius of Inventors Culminates Early in Life

By William I. Wyman

GENIUS has been defined as the ability to take great pains, while the common conception of this quality is facility of accomplishment without undue excess of effort. Probably the truth is an aggregate of these apparently contradictory ideas. In examining the achievements of men of transcendent note it is to be observed that in most cases, especially in scientific and artistic endeavors, they gave very early in life decided manifestations of unusual brilliancy. The consciousness of superior powers is, naturally, accompanied by a driving desire to give them expression, and thus we often see in the same individual powers of acutest imagination and quickest comprehension coupled with tireless energy and mastery of endless detail. Napoleon was quick to see and almost as quick to act, but he worked longer and more intensely than any of his compeers. Mozart and Raphael, highly precocious, whose arts came to them with excessive ease, left a prodigious heritage of their drudgery in the very short time they lived, while the enormous output of super-men like Newton, the scientist, Shakespeare, the dramatist, Balzac, the novelist, Rubens, the painter, and Wagner, the composer, testified to their absorption in their work as well as to their brilliancy of accomplishment.

In reviewing the careers of the more brilliant inventors, we find that they gave evidence early in life of a decided bent toward mechanics or applied science, and that their capacity for drudgerous detail and extended, intense effort was the common hall-mark of their tribe. We do not find here such unusual outbursts of precocity as frequently distinguish the tender age of the mathematical or musical genius. Almost always the great masters of music or pure science have been youthful prodigies. Mozart composed at 5, Handel at 11, while Beethoven was second court musician at 14. Pascal at 16 wrote an original treatise on conic sections, Lagrange at 19 wrote a paper which would have immortalized the maturest mathematician, and Laplace established his primacy in the scientific world before he was 21. Henry Smith, the great English mathematician, taught himself Greek as a child of four, while Clerk Maxwell intelligently (!) investigated the mysteries of bell-wiring at the somewhat less mature age of 3. But serviceable invention calls for some exercise of the maturer faculties. Imagination and inspiration may ripen exceedingly early in life, but invention, while depending in great measure upon these qualities, has also close relation to the practical, to things which require experience and passage of years to absorb and appreciate. So it is entirely natural to expect that many of the greatest inventions should have been introduced when their authors were fairly well along in years, but what is remarkable to note is the youthfulness of the creators of a great many of the most important and revolutionary inventions at the time of introduction. Perkin invented the first aniline dye at 18—thus a mere boy laid the foundations of the immense coal-tar industry; McCormick was a youth of 22 when he made his first reaper, whose importance as an industrial factor is scarcely overshadowed by any other invention since the steam-engine; Westinghouse and Marconi about reached their majority when their original creations were first published to the world, and what the air-brake is or wireless has done is to record the high-water mark in inventive progress; the thermo-electrolytic reduction of aluminum was simultaneously discovered by Hall in this country and Heroult in France, both at the age of 23, and these two young men, just one remove from boyhood, gave to industry a new useful metal, which bids fair to rank next to copper in commercial importance; and only two years later, at 25, Heroult perfected the first serviceable commercial electric-furnace, whose transcendent importance as a factor in fundamental industrial operations we are only beginning to realize.

If we were to take an excursion into the realms of the disputable and risk making a list of the twenty greatest primary inventions of modern times, we would present the table following (chronologically arranged).

There can be no question that all of these inventions are pioneer and invested with historical importance, and whether or not a better list can be prepared, it is safe to draw conclusions from the table presented. We find the average age of production about 32, at an age when extremely few men, by and large, have made their mark. Half of these contributions, all of epoch-making character, having a revolutionary or unusually stimulating effect on some industry, or creating some new and important art, were made before their progenitors reached 30, while only four, or 20 per cent, were contributed by men over 40.

TITLE AND AGE OF INVENTOR AT TIME OF INTRODUCTION.

Title.	Age.
Steam engine	29
Cotton gin	27
Photography	40
Reaper	22
Telegraph	46
Vulcanization (rubber)	39
Sewing machine	28
Bessemer process	42
First coal-tar product	18
Regenerative furnace (Fred. & W. Siemens)	30-34
Dynamo	44
Air-brake	22
Telephone	29
Incandescent lamp	32
Gasoline engine	50
Steam turbine	29
Aluminium (Hall-Heroult)	23
Induction motor	31
Wireless telegraphy	22
Aeroplane (Wright Brothers)	34-38

If we enlarge the list and include inventions of inferior importance only to what has already been listed by adding the spinning-jenny (at 25), ether as an anesthetic (27), first synthetic products (28), the phonograph (30), carbon-zinc electric cell (30), linotype (30), steam hammer (30), ophthalmoscope (30), electric-welding (33), first modern locomotive (33), dynamite (34), electric-steel (35), cotton-spinning machine (36), hot-air blast for metallurgical furnaces (36), safety lamp (37), first practical gas engine (37), Fulton's "Clermont" (42), Bunsen burner (44), kinetoscope (46), X-ray (50), and the Jacquard loom (51), the average age is advanced to about 33.5. If the list is still further enlarged to include about 40 additional but slightly less prominent inventions, the average age of production moves up almost two years, to 35.3. Allowing every reasonable latitude of choice and confining our list of greatest inventions to 25 as data for judgment, we have no reason to alter the conclusion derived from a study of the first table. Of achievements in applied science of the very first order, those of historical and vital importance, more were invented before 33 then after, and exceptionally few were created after their sponsors had reached their prime. From 27 to 30 appear to be the most active and most ingenious years of the greatest inventors, the lower 30's showing the peak of inventive effort. The young man came into his own at this time of life with the acceleration of electrical development from 1880 to 1890. Edison, Brush, and Thomson were about 30 when they undertook the pioneer task of utilizing electricity in generation, transmission and lighting, and Sprague was scarcely that age when he installed the first modern trolley system in Richmond, while William Stanley was considerably younger than thirty when he first wrestled with the problems connected with utilizing alternating current, and Tesla just over the line when his induction motor made practical the generation and transmission of high-tension and polyphase currents.

Atrophy of the creative powers by no means exerts its baneful touch after the Oslerian 40 years have arrived. Some mighty big advances were made in the industrial arts by men in the 40's—notably the Bessemer process, the telegraph, gasoline engine, the kinetoscope, electroplating, voltaic pile, siphon recorder, and Daniell cell. But the half-century mark seems to define the limit of inspirational endeavor. Bunsen invented a vapor calorimeter at 76, and M. G. Farmer was active beyond 60 as is Edison to-day, but Harvey's process of hardening armor plate, when he was 67, is the only instance the writer has been able to find of a primary invention of large industrial or social importance that was given to the world beyond touching distance of 50. Inventive genius, while flickering out at such age, does so with a strong dying gasp, for at 50 or 51 were invented the gasoline engine, the X-ray machine, the Jacquard loom, and the modern mariners compass.

It is interesting to compare the age of achievement of inventors with those of men made famous in other walks of life. As already noted, the genius of great mathematicians and musicians almost universally breaks out at an extremely tender age. Child wonders are by no means scarce among the notabilities in other vocations. Jonathan Edwards at 10 wrote a paper on the immateriality of the soul; Goethe at 8 knew something of Latin, Greek, French, and Italian, and presumably was master of his own difficult tongue; Milton at 15 composed excellent Latin verse; and Alexander Hamilton at 13 wrote letters creditable to one of matured mind; while before he arrived at 17, Raphael's work was indistinguishable in quality from the leading exponent of the greatest art school of the time. Of the great conquerors of history, four stand out in startlingly splendid isolation. Alexander was master of the world at 25, Hannibal at 26 was commander-in-chief of the Carthagenian army, and Napoleon proved himself the greatest general of modern times at 27. Cæsar was 40 before he was permitted to find opportunity to display his terrible aptness for war, and was the only one of the quartette who was beyond the influence of boyhood when he made his military mark. And yet Moltke, the greatest military strategist of our time, remained in comparative obscurity until he was 66, and did not take his place among the great historical figures until the Franco-Prussian war, at a time when the Psalmist's allotment of three-score and ten had expired. As a rule, however, men of action and men of affairs do not come to years more fruitful of fame until they are well above 40, because the time spent in apprenticeship and service and step-by-step progress through a number of competitive grades are such large factors in determining their position. Prominent statesmen, financiers, and captains-of-industry, are frequently men who may be called old, and often great military and naval engagements have been conducted by men some distance beyond their prime. In fact, it is an exception when a statesman or financier has acquired fame in his early manhood. The highest flights of the imagination, the acutest insights into scientific truth, and the most dazzling of military operations have often been the products of comparative immaturity, but the more humdrum activities in the affairs of state or in the conduct of trade and finance require leadership of tested experience. It is this fact which makes the records of William Pitt and Alexander Hamilton (one in becoming prime minister of England at 24, and the other in being the Colonies' leading financial authority at the same age) so extraordinary—not in the inherent brilliancy of their performances, but in the extreme rarity of instances of that kind.

Inventors, being partly men of science, partly men of imagination, and to a great extent men of affairs, do not leave a record of precocity typical of the first or mature so late as the last. Their records are comparable in great degree to those of noted writers, men of the creative type and of artistic perception. Thus Milton wrote "Comus" at 26 and completed "Paradise Lost," his last great work, at 57. Shakespeare wrote his first great poem at 29 and died at 52; Thackeray published his "Vanity Fair" at 35 and reached the height of his powers with his "Newcomes" at 43; and Dickens acquired fame at 24 by his "Pickwick Papers," reached his high-water mark at 38 with his "David Copperfield," and exhausted his genius not long after 50. Examples like this could be multiplied *ad libitum*, although it is curious to note a rare departure in DuMaurier and DeMorgan, both of whom took their first fling at novel writing when they were past their prime—one at 57 and the other at 67—and achieved success and fame in the attempt. Our most famous inventor, Edison, invented the stock-ticker at 24, the phonograph at 30, incandescent lamp at 32, devised the first central station at 35, and invented the kinetoscope at 46—the comparison stops here, as his record of achievement is by no means closed.

A TABLE OF IMPORTANT INVENTIONS

Inventor.	Age	Invention	Date (Patented, Operated or Disclosed).
Perkin	18	Aniline Dye	1856
Siemens, Wm	20	Steam Engine Governor	1843
Bessemer	21	Electroplating Lead with Copper	1813
Colt	21	Revolver	1835
Marconi	21	Wireless (first patent)	1896
Westinghouse	22	Air-brake	1868
McCormick	22	First Reaper built	1831
Hall	23	Aluminium Reduction	1886
Heroult	23	Aluminium Reduction	1886
Edison	24	Stock Ticker	1871
Ellis	24*	Non-caustic Varnish Remover	1902
Crompton	25	Spinning-Jenny	1778
McCormick	25	Reaper (first patented)	1834
Marconi	25	Wireless (successful operation)	1900
Howe	26	Sewing Machine	1845
Whitney	27	Cotton Gin	1792
Davy	27	Voltaic Arc	1805
Ericsson	27	Steam Fire Engine	1830
Dr. Morton	27	Ether as Anesthetic	1846
Edison	27	Quadruplex Telegraph	1874
Brush	27	Dynamo and Arc Lamp	1876
Welsbach	27	Gas Burner	1885
Wohler	28	Synthetic Organic Compound	1828
Watt	29	Steam Engine (successful operation)	1765
Whitworth	29	Planer	1832
Farmer	29	Electric Cooker	1849
Bell	29	Telephone	1876
Parsons	29*	First Steam Turbine Produced	1884
Baekeland	29	Velox Paper	*1892
Faraday	30	Principle of Electric Motor	1821
Nasmyth	30	Steam Hammer	1838
Bunsen	30	Carbon Zinc Cell	1841
Siemens, Fred	30	First Regenerative Furnace Patent	1856
Edison	30	Phonograph	1877
Helmholtz	30	Ophthalmoscope	....
Mergenthaler	30	First Linotype	1884
Farmer	31	Electric Fire Alarm Telegraph	1851
Tesla	31	Polyphase Current Motor	1888
Edison	32	Carbon Filament	1879
Stephenson	33	His First Locomotive	1814
Thomson, Elihu	33	Electric Welding	1886
Hoe	34	Rotary Press	1846
Siemens, Wm.	34	First Regenerative Furnace Patent	1857
Otto	34	First Successful Gas Engine	1866
Nobel	34	Dynamite	1867
Eastman	34	Kodak Camera	1888
Wright, O	34	Aeroplane	1905
Edison	35	Central Station Distribution	1882
Heroult	35	Electric Steel	1898
Acheson	35	Carborundum	1891
Arkwright	36	Cotton Spinning Machine	1768
Fulton	36	Submarine	1801
Neilson	36	Hot Air Blast	1828
Mergenthaler	36	First Successful Linotype	1890
Davy	37	Safety Lamp	1815
Wright, W	38	Aeroplane	1905
Watt	38	Steam Engine Perfected	1774
Siemens, Wm	38	Regenerative Furnace Perfected	1861
McKay	39	Shoe Sewing Machine	1860
Goodyear	39	Vulcanization of Rubber	1839
Gayley	39	Hot Air Dry Blast	1894
Diesel	39	Internal Combustion Motor	1897
Daguerre	40	Photography	1829
Westinghouse	40	Quick Acting Brake	1886
Acheson	40	Artificial Graphite	1896
Bessemer	42	Converter	1855
Fulton	42	Steamboat	1807
Kelvin, Lord	43	Siphon-Recorder	*1867
Cort	44	Reverbatory Puddling Furnace	1784
Brugnatelli	44	Electroplating	1805
Bunsen	44	Burner	1855
Siemens, Wm.	44	Dynamo (with Werner Siemens)	1867
Siemens, Wm.	44	Open Hearth Process	1867
Otto	44	Finished Gas Engine	1876
Taylor	44	High Speed Steel	1900
Stevenson	45	First Successful Locomotive Operated	1825
Daniell	46	Battery Cell	1836
Morse	46	Telegraph	1837
Edison	46	Kinetoscope	1893
Volta	47	Voltaic Pile	1792
Kelvin, Lord	50	Mariners' Compass, Modern	*1874
Daimler	50	Gasoline Engine	1884
Roentgen	50	X-ray Machine	1895
Siemens, Werner	51	Dynamo (with Wm. Siemens)	1867
Jacquard	51	Loom	1801
Ericsson	52	Hot Air Engine	1855
Daimler	52	Gasoline Vehicle	1886
Morse	53	Telegraphy Publicly Demonstrated	1844
Ericsson	60	Monitor	1862
Harvey	67	Harveyized Steel	1891

* Approximately.

Distribution of Nebulæ

A DISCUSSION of a systematic search for nebulæ in Kapteyn's "Selected Areas," by E. A. Fath is given in the *Astronomical Journal*, plates having been taken covering 139 out of the 206 regions comprising the scheme. The exposures were made with the 60-inch reflector at Mount Wilson, and each lasted one hour. A number of new nebulæ are noted, and an interesting series of conclusions as to the general distribution are given. The concentration of nebulæ near the north galactic pole is very noticeable, but there are great variations in the density of distribution. There is a complete absence of these nebulæ where the Milky Way crosses the sky.

Prism With Curved Faces

ON previous occasions, Mr. C. Féry has, and he now describes in the *Journal de Physique*, how a prism with curved faces, one of the curved faces being made reflecting, can be used in the construction of a spectrograph; how such prisms may be employed generally to give a pure spectrum, even though the incident beam is not parallel. If the beam is divergent a concave face is used for the incident light, and a convex face when a convergent beam is employed. The diacaustic of such a prism is situated on a circle, whatever the dispersive properties of the material, and this circle contains the centers of the curved faces of the prism. A description is given of the way in which prisms with curved faces may be used (i) for transforming a convergent beam into a spectral image, e. g., the image of a star furnished by an astronomical objective; (ii) for the study of infra-red spectra; and (iii) for the study of ultra-violet spectra.

How Dirigible Airships Are Charged With Gas on the Battlefield

Portable Plants for Military Use

THE progress recently made in developing the spherical balloon and especially the airship for military or other uses, has caused increased attention to be paid to methods for producing hydrogen gas in large quantities to meet the growing needs and in a sufficiently pure state. Of late the extensive use of airships in some countries, as a part of the army outfit, has led to a search for suitable hydrogen-producing plants especially adapted for military use. Fixed hydrogen plants are of course useful in connection with aeronautic establishments and army centers, but what is especially valuable now is a portable outfit of this kind which can follow the army's movements throughout the country so that the airships can be supplied in the best manner. By the adoption of a hydrogen plant mounted upon railroad cars such as we represent here, it will be seen that the effective work of an airship will be at once increased, owing to the fact that it is constantly kept in good order by the available supply of gas. Wanting this, the airship would often be laid up, or at least subject to more or less delay in carrying out its work.

A hydrogen plant of the present kind not only serves for aeronautic purposes, but the gas can be supplied from either fixed or movable plants for use in different industries developed within the last few years, such as electric welding of plates or bars, and similar work for which a considerable amount of hydrogen is needed at present, also for cutting of plate iron by the hydrogen blowpipe. The hydrogen-producing methods used mainly up to now are purely chemical, electrolytic, or regeneration processes, but all have their disadvantages as compared with the present oil gas method which is used by the inventors. In some cases the first cost or operative expenses are high, and in others the gas needs to be produced on the spot where hydraulic or other cheap electric power can be employed or in the other cases where a water gas plant can be installed to advantage. In such cases the hydrogen needs to be transported in steel bottles under pressure, which is an added cost. Some processes do not give a pure enough hydrogen, one which shall be free from arsenic and chlorine, and it is known that arsenic has caused even mortal accidents in this way. As to chlorine, the gas for use in airships must be free from it, for chlorine attacks the balloon envelope.

According to the new German hydrogen process devised by Rincker and Wolter, the gas can be produced in any suitable place and the plant occupies but a small space, with a very cheap production. At the same time the compact shape of the apparatus makes it very well adapted for mounting upon cars so as to give a portable plant for airships. In fact, it appears that the German army is much interested in the present method and expects to use it for supplying airships of its numerous fleet. The gas which is produced in this apparatus has but a small percentage of nitrogen and has a specific gravity of 0.087 to 0.092. The operation is based upon the use of crude oil to produce the gas, so that a supply is easy to have. Instead of this, the producer can also be made to work upon benzine, refined oil, benzol and the like. Heating is done by the use of coke, as a general rule, although this can be replaced by charcoal. In the large engraving will be seen the general makeup of the plant mounted upon two railroad cars such as is designed for use in the field in army operations. In this apparatus the first part consists of the gas producer layout which is mounted in complete shape upon the front car, while the second car has the remainder of the plant, including the cooler, scrubber, and other purifying devices. This second part of the apparatus is especially needed for giving pure gas which airships require, as otherwise it need not be as elaborate for use in other industrial processes where less pure gas is needed.

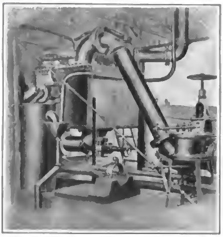
The main apparatus on the front car consists of a pair of gas producers. Each of these has a heavy plate iron casing which is lined with firebrick. To remove slag and ash, there are two doors in the front which are kept closed while the gas is being produced. On the top of the apparatus is a hopper for use in feeding in the coke. At the bottom of the producer are good-sized pipes which bring in the air blast from the blowing chamber. The first of the two producers also has an oil spray device for introducing the oil at the top part. The producer is filled up with coke as is usual in such cases, and hot air is sent in at the bottom coming from a steam turbine driven blast fan, this being worked by the steam from the locomotive. If need be, the blast fan can also be driven by a gasoline motor or crude oil engine of the usual kind, in the case of the portable plant; or with a stationary plant, a gas engine, electric motor or any suitable mechanical drive can be used.

Oil for the spray is supplied by a suitable oil pump which feeds from a large tank on the car. It is necessary to heat this oil before feeding it into the producer, and the steam from the turbine is brought to the tank for this purpose, so that the heating is economically done. At the start of the apparatus, both producers are filled with coke and fired up. By the use of the hot air blast the coke is brought to a white heat, and during this time the coke gases are carried off through the opened top cover and escape into the air through the plate iron chimney. The blast is now stopped and the top cover closed down, whereupon the oil spray is set working, and the oil is transformed into oil gas, this being obliged to pass through the heated coke of the two generators in succession. In this way all the light as well as heavy hydrocarbons are decomposed and the result is a high grade of hydrogen gas containing from 90 to 96 per cent pure hydrogen. Before the producer is actually working to deliver the pure gas to the rest of the apparatus, care is taken to evacuate the gas which was already contained within the producers, and the first part of the newly produced hydrogen is allowed to escape by way of a special valve which is fitted on for this purpose, according to a patented method. During the usual working of the producers, the passage of the gases through the hot mass of coke causes the temperature of the coke to become eventually lowered, and when it cools down below a certain point there will be no more gas generated. When this is the case, the oil feed is stopped and the hot air blast again turned on so as to fire up the coke mass as was done in the first place. Then the oil spray is turned on and the process repeated. Thus the method is an intermittent one, and consists in an alternate operation of the oil spray and hot blast. Firing up the coke by the blast usually takes 2 or 3 minutes during the run, that is, when the coke is still hot, then the gas production lasts for about 20 minutes, and so on.

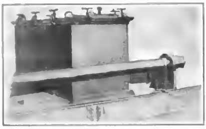
From the second producer the gas goes by good-sized piping into a device which is provided with a water seal (shown in the first engraving) in order to prevent a back flow of gas during the period when the hot air blast goes through the producer. Care is taken in all cases to keep the hydrogen from becoming mixed with air, as is of course quite essential. The gas then passes into the second car by means of coupled piping. On the front end of the car is mounted a well-designed scrubber which is designed with water flow so as to clear the gas of all mechanical impurities such as ash or soot. The scrubber consists of a plate iron case which is filled up with the washing elements of patented makeup, a water flow being introduced at the top, while the gas comes in at the bottom of the scrubber. Means are provided for dividing the gas flow, so that it comes into as good contact as possible with the water.

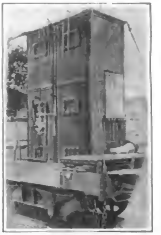
Next the gas comes into a cleaner which works on a dry process shown in the illustration, and it is designed to remove any sulphur compounds contained in the gas. Here the cells of the cleaner are filled up with a suitable compound which acts as a filter for the gas. For some uses of the hydrogen, the purifying process can stop at this point, as the gas is sufficiently pure for many industrial uses as may be seen by the following analysis: CO_2, 0.0 per cent; O, 0.0; CO, 2.7; CH_4, 0.0; H, 96.0; N, 1.3. The specific gravity of the gas is about 0.1. For such purposes it is not necessary to free the gas from carbon oxide or nitrogen. Next the gas is freed from moisture by sending it through a sulphuric acid dryer pictured in the small engraving and mounted after the other two devices upon the car platform. Last comes a heating furnace for removing the carbon oxide, the furnace being heated by oil gas. Then the gas goes to a cooler, which is built together with the first-mentioned scrubber. Analysis is then as follows: CO_2, O, CH_4 = 0.0; CO = 0.4 per cent; H = 98.4; N = 1.2. Sp. gr. = 0.087 to 0.082.

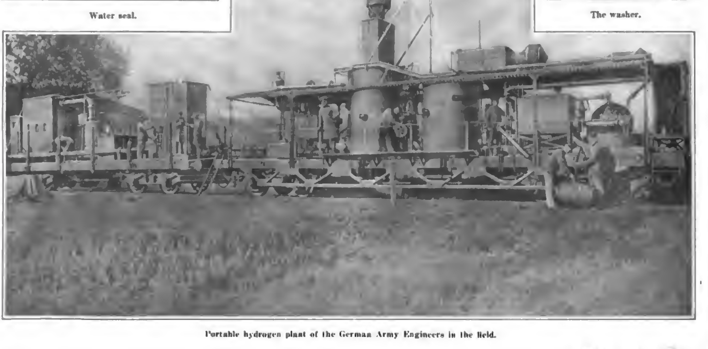
Firing up takes 1 to 2 hours, and the plant can be run for months at a time, needing but two men. The plant follows the airship and either supplies it direct, or where too far off, by a special outfit provided with steel gas bottles. To this end a third car can contain a compressor tank for charging the bottles. In any case these need not be carried to any very great distance in order to reach the airship.


Water seal.

Acid cleaner.


Dry cleaner.


The washer.


Portable hydrogen plant of the German Army Engineers in the field.

Electric motor dragging an ammunition caisson through a hole with steep sides.

Recoil siege cannon upon carriage drawn by horses, clearing a wooden obstacle at the testing ground of Tangerhütte.

How German Artillery is Tested Before It Is Used on the Battlefield

The Krupp establishment is making use of some very efficient endurance or breakdown tests upon artillery, both for keeping up a check upon the standard types of pieces, and for testing new designs. One of the most novel methods is the use of a circular, electric, testing track, upon which a car is run in order to draw the artillery pieces over the ground at slow or high speeds as may be required.

At the Essen artillery grounds, which lie near the main factories, there is laid out a circular railroad track with a special kind of electric car running upon it, for making the tests upon the artillery. The track has 210 feet mean diameter, which gives it a total length of about 650 feet, being substantially laid on beton and using a single rail on the outer side and a double rail on the inner circle so as to keep the car from running off the track. The railroad track proper is usually reserved for the electric car, while the artillery is run on a circular way, which lies on the inside and also on the outside of the main track, thus allowing two pieces to be drawn along at the same time. The artillery track is slightly banked. The railroad track has a 7-foot 6-inch gage, and, if desired, the artillery can also be run in the space between the rails. In order to vary the tests, the nature of the ground is made different upon various parts of the circular tracks. For instance, some 320 feet of the track or about half the circle is laid with a good stone paving, while the remainder represents country roads in more or less good condition. Upon these different stretches of road there can be placed obstacles of various kinds such as timber lying across the road, ditches or holes and the like. The use of the electric car for drawing the artillery has an advantage from the great number of different running speeds which can be employed, representing what a team of horses would give at a trot or gallop; and much higher speeds can be used when desired.

On the upper floor of the cabin is an inspection room, which serves for engineers or official committees when making certain tests upon the artillery, whence the track can be overlooked. Signals can be sent from the track into the cabin in order to give notice to the operators, and for this use there are placed six signal posts around the track so as to send electric bell signals to the cabin during the maneuvers for changing speed or stopping and the like. Across the car is a bar to which the tongue of the artillery piece can be attached so as to run it on the outer, middle or inner track. The car is started up and the piece is taken around at the different speeds which may be required for any given case, so that it will be seen that the electric truck allows any such maneuvers to be made very quickly and avoids loss of time. As regards the obstacles which are put in the way of the artillery piece to give it a severe endurance test, one of our engravings shows a field howitzer taken over a heavy piece of round timber and at a high rate of speed. Seeing that the artillery piece springs up to a considerable height and then falls on the ground, and that its total weight is 2.4 tons, an idea of the good quality of the axles and wheels will be obtained. Another illustration represents an ammunition wagon being drawn at a high rate by the car and passing over a steep ditch dug on the track at this point. It should be stated that the track is well lighted by arc and incandescent lamps. Up to the present time the tests which cover a period of several years amount to as much as 40,000 miles run upon the circular track.

Some very severe tests of another kind are obtained by the use of steam locomotives running on a special stretch of railroad track at the company's artillery grounds at Meppen. At each side of the track is laid out a proving way containing surfaces of varied character or special obstacles. Our engraving shows two artillery pieces attached to a cross-bar, each running on a separate way. Here the road is made up of heavy broken stone. When the locomotive is run at high speed this gives a very severe test, and in some cases the artillery pieces jump bodily from the road to a considerable height. This is the case in our present figure, where the obstacles consist of railroad rails laid crosswise and spaced along the way.

Other endurance tests of artillery are made upon actual roads in the country, using a team of horses as one of our photographs shows. The field piece is here passing over a very high obstacle formed of three logs bound together, and it springs a conspicuous height off the road.

The Synthetic Power of Protoplasm*†

From the point of view of the biological chemist the phenomena of life are manifestations of interactions of colloidal and crystalline materials in a peculiarly organized solution; over and above this every form of protoplasm, existent in any organism, is stereochemically ordered in specific relationship to that organism, so that the products of synthesis have an impressed structure and manifest optical activity. It has been suggested by Prof. Armstrong that the protoplasmic complex may be regarded as built up of a series of associated templates which serve as patterns against which change takes place in the various directions necessary for the maintenance of vital processes. This view is based on the well-known relationship between an enzyme and its hydrolyte; the synthetic enzymes, it may be supposed, serve as patterns for the elaboration of complex materials of definite pattern.

In speculating on the origin of organic life from inorganic material Prof. B. Moore has ignored this stereochemical aspect of the question. His use of the well-known synthesis of formaldehyde from carbon dioxide and water in presence of an inorganic catalyst—in his case a colloid—can lead only to optically inactive material, and there is no justification even for the mention of the term life until evidence of directed synthesis is adduced.

The stereochemical hypothesis enunciated has been advocated by Prof. Reichert of Pennsylvania in his researches on hæmoglobin, in which he showed that this substance is modified in specific relationship to genus and species. He now extends the hypothesis to the study of starch, expecting that the peculiarities of the protoplasm in different species of plants will occasion the formation of different types of starch. The variations in the starch granule with origin are, of course, well known, and they are of industrial importance. They are now shown to be absolutely diagnostic in relation to the plant and to constitute a strictly scientific basis for the classification of plants. In addition to recording the microscopic characters of the starches an attempt has been made on a large scale to characterize them chemically, and although these tests are admittedly crude and leave much to be desired, they do mark a great advance in the treatment of the subject.

It may be regarded as established that starches of different origin vary both visibly and in chemical properties; moreover, plants of closely allied species contain starches with similar properties, and it is logical that such variations must be attributed to the differences of protoplasmic influence under which the starch granules are formed. It must not be overlooked, however, that starch granules are made up of three kinds of substances, namely, the true starch degradable to maltose, which forms the bulk of the granule, amylocellulose or amylopectin, and a small proportion of carbohydrate, possibly crystalline, soluble in cold water. It is probable that these are present in different proportions in the various starches, and so give rise to such differences as Reichert has observed.

Some valuable observations on the characters of hard and tender barleys, published by H. C. A. Vine in the *Journal* of the Institute of Brewing, may be mentioned in this connection. A barley corn may contain starch granules of all sizes, the variation being due to the conditions under which it develops. Malnutrition of barley leads to a high ratio of small starch granules which are more resistant to enzyme action, to moisture and to heat than the normal mature granules. Those granules which have the more favorable position in the inclosing cell are able to appropriate a large proportion of the nutriment supplied by the protoplasm and so become normal large starch granules, each consisting of many layers containing much granulose, tender and readily acted upon.

Similar observations were made by the writer some years back when it was pointed out that there is considerable variation in the proportion of large to small granules in wheat starch. Those types of flour which are the best for certain purposes contain the greatest proportion of large granules, the property being quite characteristic.

Hence it would seem that, over and above species variation, differences due to environment and nurture may appear in the starches, and it is possible that the further study of such a substance as starch may provide material for the solution of many vexed problems.

In addition to the detailed account of the tests applied to each starch, which are recorded also in the form of a curve which is shown to be characteristic for each individual, Prof. Reichert includes in his book a beautiful series of photomicrographs taken in ordinary and polarized light. These enhance very materially the value of the work, although they must have increased greatly the cost of publication. The author has further been at pains to summarize at some length previous work on starch, both on the chemical and on the botanical side. His account is a valuable one if only as showing how much uncertainty exists at present in the knowledge of starch and its transformations.

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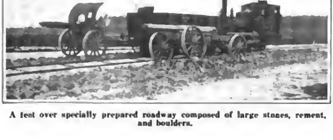
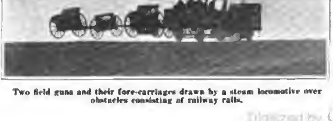
* Reproduced from *Nature*.

† "The Differentiation and Specificity of Starches in Relation to Genera, Species, etc." Stereochemistry Applied to Protoplasmic Processes and Products, and as a Strictly Scientific Basis for the Classification of Plants and Animals. By Prof. E. T. Reichert. In two parts. Pp. xvii + 900 + 102 plates. (Washington, D. C.: Carnegie Institution of Washington, 1913.)



A test over specially prepared roadway composed of large stones, cement, and boulders.



Two field guns and their fore-carriages drawn by a steam locomotive over obstacles consisting of railway rails.

The Flying Machine from an Engineering Standpoint—V[*]

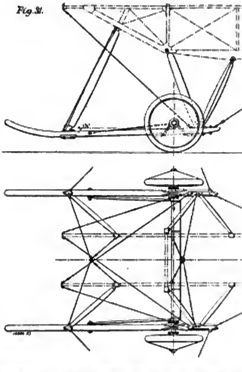
A Review of Recent Progress

By Frederick William Lanchester, M. Inst., C.E.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2017, Page 144, August 29, 1914

12. *Landing Gear.*—8. The question of alighting mechanism detail next claims our attention; this is necessarily of two distinct types, depending upon whether the machine is designed for land or for marine usage. Taking first the land or military type of machine, the essential features comprise, ordinarily, a pair of pneumatic-shod wheels (in some cases, two pairs) arranged on a common axis somewhat forward of the center of gravity of the machine, and supplied with a rudimentary elastic suspension of some form, in addition to runners or skids to take the "bump" in emergency, and the provision of some kind of temporary tail support, consisting either of a caster-pivoted wheel, or (as more generally the case) of a simple spring-controlled skid. It was at one time believed to be essential that the alighting wheels should be all caster-pivoted or orientable, the intention being to take care of the relative motion of the ground when alighting across the wind;[†] experience appears to show that with reasonably careful handling this provision is unnecessary. Two types of suspension are illustrated in Figs. 31 (Royal Aircraft Factory) and 32 (Blériot); it will be noted that in both cases the medium employed to absorb the shock is rubber; this is preferable to steel (as universally employed on road vehicles) for two reasons: first, the energy good vulcanized rubber will absorb is far greater than is the case for steel; it runs to some 500 pounds to 1,000 pounds per pound (some 10 or 20 foot-pounds is all that may be allowed for steel); and secondly, the signs of fatigue in rubber are evident to the most casual observer, and the rubbers are cheap and easy of replacement. The alighting wheels with their associated parts are mounted on a structure commonly known as the landing-chassis, whose function is to raise the machine proper a sufficient height above the ground to provide clearance for the propeller, aerofoil, etc.; unless careful design and workmanship are put into the landing chassis its "spidery" proportions necessary to give clearance may, on the one hand, constitute a source of weakness, or, on the other, give rise to excessive resistance. Owing to the liability of the landing chassis to injury it is clearly desirable that its structure should be complete within itself, yet this is very difficult of achievement in actual design; more often than not there are members in common to the landing chassis and the aerofoil structure or the fuselage. This must be considered a weak point in any design, since it involves the risk that some essential flight organ may on landing be strained or otherwise injured, or at least stressed beyond the limit for which it had been designed.

Fig. 31.



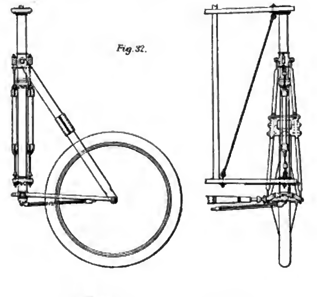
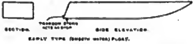


Fig. 32.

Fig. 33



EARLY TYPE (SMOOTH WATER) FLOAT.

In spite of all that has been done up to the present, the landing chassis is only able to take a very moderate "bump" with safety, a 1-foot free fall onto a hard surface is as much as can be deemed safe in the best of existing machines; a free fall of 4 feet or 5 feet would lead to almost certain failure. This requires that, in landing, a machine should never, under any circumstances, be allowed to take the ground with a greater vertical velocity component than 8 feet per second. Assuming a gliding angle of 1/7, this means that a machine, flying at 38 miles per hour (56 feet per second or foot-second) could be allowed to take the ground (presuming the latter horizontal), without intervention of the pilot; but for any higher velocity of flight its course must be eased or flattened. In actual practice it is, of course, part of the art of flying to avoid all shock when alighting, no pilot would think of taking the ground without at least making his best effort to flatten his angle of descent. There is probably a future for some form of hydraulic pneumatic device; already several attempts have been made in that direction.

Passing now to the marine type, we find in the earlier examples a landing chassis of the ordinary pattern fitted with a pair of floats in place of wheels and skid, and a temporary tail support in the form of a third float arranged aft under the tail member. In the earlier machines these floats were little more than boxes of rectangular section, Fig. 33; recently there has been a tendency to give to the floats a more boat-like form,[‡] surfaces of single or double curvature being adopted in place of flat, and so the liability to being stove in has been reduced to a minimum. The double float support has proved itself suited to comparatively smooth water, but a strong feeling exists at the present time that for machines intended to serve on the high seas that construction will be abandoned in favor of the single central boat, as already to be seen in the Curtiss and Sopwith machines (Fig. 34); here auxiliary floats or bob-floats are fitted to the extremities of the aerofoil to give stability to the machine when resting on the water, and to avoid damage to the aerofoil when getting under way or when alighting.

The main floats, whether single or double, require to be constructed to rise in the water on the same principle as the so-called hydroplanes or skimmer craft, being designed with the usual stepped bottom; a single step is found to give the best results.

The design of floats or hull for a marine machine must be regarded as still in an early stage of development, and much will depend in the future on the general evolution of the machine as to what form of float gear will ultimately be found most appropriate. The author is of opinion that, as a development of the single-boat type at present existing, it would appear to be desirable to bring the motor or motors, and other heavy parts as far as possible, down into the hull, and design the boat as a thoroughly seaworthy craft with proper metacentric height and fitted with its own (marine) screw-propeller, so that it is capable of being navigated independently of its flight organs (Fig. 35). In such a design it would evidently be necessary to drive the propellers through a belt, chain, or gear of some kind, and mechanism would be provided by which the pilot could jettison the superstructure in emergency. Such a machine would be essentially one of considerable size, and would probably be fitted with two, three, or even more engines, with a total of over 500 horse-power. The weight of such a machine would require to be some 3 or 4 tons, and would be capable of making port under its own power if the flight organs were abandoned.

13. *Acentric Types of Machine.*—The type of machine here suggested would be liable to certain objections on the ground that the line of the propeller thrust is acentric, being situated considerably above the center of gravity, and probably also above the center of resistance of the machine; conversely, the center of gravity would be considerably below the center of resistance; these are objections which have been raised with regard to some existing machines. It is undoubtedly desirable, where other considerations permit, to bring the center of propulsion, center of resistance, and center of gravity to approximately the same level. There is no fundamental difficulty in flying a machine in which this condition is not complied with, since any pitching moment that results from the want of concentricity can

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[*] The James Forrest lecture, delivered before the Institution of Civil Engineers on May 8th. Compare also the same author's paper on "Catastrophic Instability in Aeroplanes," SCIENTIFIC AMERICAN SUPPLEMENT, February 14th, 1914, page 98.

[†] Messrs. Voisin Brothers, in the days of their pioneer work, attached great importance to this point. They attributed the early success of Farman (on his Voisin machine) largely to the fact that this feature was embodied in his machine.

[‡] An instructive series of trials have been made in the Yarrow Tank at the National Physical Laboratory. Advisory Committee Report 1912-13, Memorandum No. 70 (Baker and Millar).

be corrected by suitably arranging the center of gravity. Serious difficulty, however, is liable to arise in the event of a sudden change in the mode of flight, such as is brought about when the engine is cut out. Under these conditions, the machine being propelled in gliding flight by a component of gravity instead of by the propeller thrust, a change of pitching moment takes place equivalent to the total resistance of the machine, multiplied by the vertical distance between the line of propulsion and the center of gravity. In a machine of the type above suggested, such a change of moment would be the equivalent of a movement of the center of gravity through a distance of nearly 2 feet, a change which we must regard as of dangerous magnitude.

Fig. 34

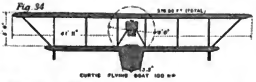


Fig. 35.

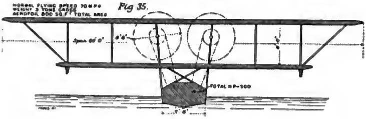


Fig. 36.

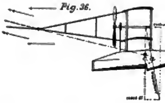
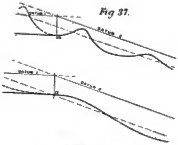


Fig. 37.



The position is that shown diagrammatically in Fig. 36, in which it will be seen that the resultant of gravity and the propeller thrust passes some considerable distance in front of the center of gravity, whereas in gliding flight the resultant of the lifting and propelling forces is the force of gravity, and so passes through the center of gravity.

It has been suggested that by arranging the tail-plane (and elevator) in the wake, in the propeller slip-stream in fact, and giving it an upward rake, in other words, by employing a negatively loaded tail, the tail may be made to supply a countervailing pitching moment when the propeller is at work; thus, while the direct effect of the propeller is to tend to lift the tail and depress the nose of the machine, the indirect affect brought about by the action of the slip-stream on the upturned tail will be the inverse. It might be possible in this way to correct a small want of concentricity of the propeller axis, but such a method would scarcely be applicable to the case in point. In order that the method in question should be effective, the slip-stream must be discharged radially from the center of gravity of the machine; that is to say, the general body of air discharged in the slip-stream must be so deflected that its moment of momentum about the center of gravity is zero. Roughly speaking, this means that the tail, as shown dotted in Fig. 36, must be set at such an angle as, if produced, would pass through the center of gravity of the machine; the double-headed arrows show the slip-stream diverted as theory requires. The method is evidently impracticable; not only is the tail angle as necessitated altogether excessive, but also the whole story has not been told—the tail would require to be "feathered" immediately the propeller ceases its function, otherwise it would continue to supply a moment of some magnitude when no longer required.

It is of interest to examine in greater detail the behavior of a machine such as we are considering under flight conditions. It is clear that if at any instant the engine is switched off, two things happen: First, as in a machine of the concentric type, the supply of energy being withdrawn, the datum of the phugoid chart takes a downward trend; its down slope is that of the gliding angle, Fig. 37, datum 2. Secondly, since the withdrawal of the thrust, reaction is in effect equivalent to a movement backward of the center of gravity, the angle of attack of the aerofoil is increased and the natural velocity of the machine is reduced, and H_e is diminished to a corresponding degree. The conditions are thus represented by the upper diagram in Fig. 37; the reduction of H_e being calculated, we consult the phugoid chart and select the curve to correspond; as shown, this has been taken as curve G from Fig. 2. In the lower diagram, Fig. 37, a similar construction has been shown for a machine nearly concentric as to its thrust; the resulting phugoid here corresponds to that labeled C in Fig. 2. The case of least disturbance is that in which the original flight path picks up the new flight path at its point of inflection; that is the case if the propeller axis is slightly below the center of gravity, since then on cutting out the engine the value of H_e is slightly increased; this is as actually represented on the lower diagram.

Fig. 38a.

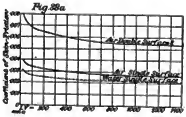


Fig. 38b.

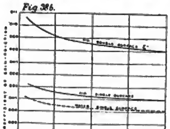
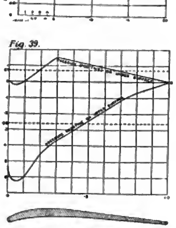


Fig. 39.



At present there are difficulties of the character and extent outlined standing in the way of development in the direction indicated; they are difficulties that will without doubt be eventually overcome.

14. *Stability and Control.*—In the present lecture all questions of stability in the ordinary sense have been taken for granted. The problems of longitudinal stability, lateral and directional stability, and spiral or rotative stability, though of vital import to the aeronautical engineer, are primarily matters for the physicist and mathematician; the engineer can well afford to leave questions of this character in the hand[illegible] the specialist.

There is perhaps less excuse for the absence of all mention of controlling mechanism; a great deal might be added on that subject, without going beyond the scope of the title. However, since the question of control is closely wrapped up with considerations relating to stability, and since it is necessary to draw a line at some point, the omission is one of expediency rather than logic.

The question of stability is not, as is frequently supposed, one that is in any sense obscure; in fact, from the scientific point of view, the present position is at least satisfactory; it can be said without exaggeration that we have a great deal more knowledge on the subject than we are at present able to utilize.

There is very little of importance, specifically relating to the stability of the flying machine, that has been written, either before or since, that will not be found either in the work of Dr. Bryan[8] or in "Aerial Flight."[9] A few notes have appeared in the various reports of the Advisory Committee for Aeronautics, but not very much; two short notes of a somewhat trivial character appear in the report of 1909-10, in addition to an excellent abstract of Soreau's "Etat actuel et avenir de l'Aviation."[10] In the reports for 1910-11 and 1911-12 there is nothing; in the report for 1912-13 there are two or three interesting communications, mainly due to the staff of the National Physical Laboratory, notably memoranda Nos. 77, 78, and 79. No. 77 (L. Bairstow, Melville Jones, and A. W. H. Thompson), is, in the main, an examination and extension of existing theory following the methods initiated by Dr. Bryan; No. 78 (L. Bairstow and L. A. MacLachlan), mainly relating to the determination of the various coefficients required for the application of Dr. Bryan's method of treatment. No. 79 (L. Bairstow), dealing with the more detailed application of the same method. These communications are conspicuous by the fact that their authors appear to be really au *courant* with the previous literature of the subject.

Fig. 40

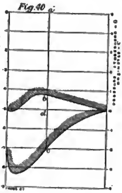
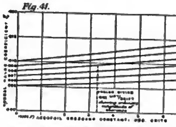


Fig. 41.



The work that has been done on the Continent on the subject of stability does not in sum amount to much; moreover, it frequently appears to suggest complete ignorance of what has been done in this country; in this particular matter it would seem that the Continent has become insular and our island cosmopolitan. For example, we find the work of Georges de Bathezat,[11] described by Mr. Painleve as "the first to give an exact and complete discussion of the stability of the aeroplane"; and when we examine the work so described, we find the subject not more than half dealt with, and at that in so ineffective a manner that scarcely one of the conclusions can be regarded seriously. R. Knoller[89] and Reissner,[90] though interesting, do not materially advance the subject. H. Soreau deals with the subject of longitudinal stability under two distinct headings—equilibrium and stability; so far as the former is concerned, his conclusions as formulated will be found in their entirety published by me in 1897, with the *rationale* clearly set forth.[91] Soreau, however, scarcely carries the matter as far as in my previous publication. Incidentally, Soreau gives two propositions, i. e., minimum tractive force and minimum horsepower, which, except for differences of notation, appear to be identical with two propositions previously given by me in "Aerodynamics," 1907, sec. 164. When we come to the question of stability, it will suffice to state here that his conclusions on the subject of longitudinal stability are gravely at fault; briefly, Soreau states that the moment of inertia must not be too small for fear of oscillations becoming too rapid, whereas the only oscillation of importance—my "phugoid oscillation"—is virtually independent for its period on the value of the moment of inertia. On the questions of lateral stability and directional stability, Soreau's views (as pointed out by Bryan) are entirely at fault; the whole question of asymmetric or rotative stability is lost sight of, and the fact that in directional stability the center of gravity cannot be treated as a static pivot[92] is ignored.

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[8] G. H. Bryan, "Stability in Aviation," Macmillan & Co., 1911.

[9] "Aerodonetics," vol. II. Constable & Co., 1908.

[10] Mémoires, Société des Ingenieurs Civils de France.

[11] "Étude de la Stabilité de Aeroplane." Dunod, Paris, 1911.

The work of Capt. G. A. Crocco[93] is of interest. In the main he follows established mathematical lines of treatment. I have made no attempt to follow his work in detail. Capt. Crocco's conclusions on the whole appear to be far sounder than those of most Continental writers; his work is evidently worth careful study.

The above may be taken as a brief summary of the existing literature of the subject. Excellent abstracts of the work of the foreign authors cited will be found in the appendices to the various reports of the Advisory Committee; excepting in the case of the French writers, which have been consulted in the original, I have relied on the abstracts in question for the summary here given.

APPENDIX I.

The subject of skin friction where air is concerned has been one of considerable controversy. The quantities to be measured are so small, and the apparatus employed until recent years has been so insensitive, that until the work of Zahm in 1904 very little was known on the subject. Langley, in his "Experiments in Aerodynamics," 1891, asserted skin friction to be a negligible factor in its relation to flight. Dines about the same date expressed the same view. In my "Aerial Flight," vol. I., which appeared in 1907 (not at that time aware of the work that had been done by Zahm), I published some determinations of skin friction, and attacked Langley's views, pointing out that skin friction is one of the controlling factors in the economics of flight. I also introduced the practice of expressing skin friction as a coefficient representing the resistance of a thin lamina in tangential motion in terms of its resistance at 90 degrees; the coefficient so expressed is the double surface coefficient, and in my work is represented by the symbol ξ. In the greater part of my experimental work, planes or laminæ of mica were employed of but a few square inches area; the largest area used by him in any of his determinations was approximately ½-square foot. Now it is well established that the coefficient of skin friction in a plane of small area is sensibly greater than in one of large area, consequently my values were on the whole considerably higher than those of experimenters working to a larger scale; however, the following passage may be cited as the summary of experiments made with planes of about ½-square foot area, and of smooth surface: "It is, therefore, to be concluded that for a well-varnished surface or for polished metal, under the conditions of experiment, the effective value of ξ is approximately 0.008 with a probable error of less than 10 per cent, plus or minus."[94] According to the best estimate that can be made to-day the actual value of the double surface coefficient under the conditions of the experiment in question should be 0,0081, showing an error of precisely the 10 per cent which I allowed myself.

In a communication to the Advisory Committee for Aeronautics (Memorandum No. 15, June, 1909), I pointed out that my own results and those of Zahm for air, and the results obtained many years ago by W. Froude for water, are in substantial agreement—in fact, in very close agreement—provided that they are put in their proper perspective, with due consideration to the laws of dynamic similarity.[95] The conclusion given in the memorandum under discussion is expressed in graphic form in Figs. 38*a* and 38*b*, in which the abscissæ represent the quantity $L\,V$ (the product of the linear dimension[96] in feet by the velocity in feet per second), and in which ordinates represent the coefficient of skin friction. Three curves are shown; the upper curve is the double surface coefficient for air, for which I employ the symbol ξ, the lower curve (solid line) is the single surface coefficient (half the value of the former), the dotted curve is the coefficient for water. In Fig. 37, $L\,V$ values may be read from 20 to 1,400. In Fig. 38 is given a graph for lower values.

It is a point not without interest that, for geometrically similar aerofoils, the weight sustained varies as $(L\,V)^2$, consequently for any given value of $L\,V$ the weight is constant. In other words, as already shown, for least resistance $P = C\rho V^2$, where C is a constant whose value is round about 0.32, or if $k\,L^2$ represents the area, and W = weight,

$$W = 0.32\,k\,\rho\,(L\,V)^2.$$

Therefore, assuming good design (max. lift/drift), and some definite value of aspect ratio (to fix the value of the constant k), the coefficient of skin friction is determined by the weight of the machine, and is the same whatever the designed velocity may be.

Skin friction has a habit of playing an elusive part in actual resistance phenomena, and the subject in practice is full of pitfalls. In the case of a plane moving edgewise, it may frequently happen that skin-frictional resistance will virtually disappear, the leading edge of a plane, such as used by the late Prof. Langley, will by its bluffness set in motion a certain quantity of air, and this moving air subsequently washing the surfaces of the plane will reduce the skin-frictional resistance to something immeasurably small; as pointed out by me in discussing Langley's work, this was one of the causes that led him into error.

Another case where the coefficient of skin friction may be abnormally low is that of the inclined plane at a small angle of incidence; in "Aerial Flight," vol. I., the matter is dealt with on page 261, article 182; it is pointed out that as a deduction from gliding experiments made with the ballasted plane, and calculations based on them, the coefficient of skin friction is in effect less than ordinarily the case, and the explanation is offered that the upper surface of the plane being to a certain degree a "dead-water region," the coefficient may in this case be only that of the single surface. This conclusion has received striking confirmation in connection with some experimental work recently carried out at the National Physical Laboratory.[97]

I consider it probable that in the case of the pterygoid aerofoil—that is to say, the aerofoil of arched section, such as shown at the foot of Fig. 39—the skin friction may in effect be abnormally high, owing to the augmented velocity with which the air flows over the upper surface. This, speaking generally, is not altogether compensated by the lower velocity on the under side. The velocity of the air in the vicinity of the aerofoil can be deduced approximately from the ordinary laws of fluid motion from the local pressure. Now pressure curves have been made of several different sections of aerofoil by the National Physical Laboratory; the curve shown in Fig. 39 may be taken as roughly typical of the pressure graph for mid-section of any well-shaped aerofoil at or about its angle of least resistance. The ordinates downward from the zero datum line being negative pressures on the upper surface of the foil, and the ordinates measured upward from the said datum line being the positive pressures on the under surface, in both cases measured above and below atmosphere. Plotting the same curve in Fig. 40, and taking a datum line corresponding to zero motion, ordinates will represent fluid tension (negative pressure), and the velocity at every point is represented by the square root of its ordinate; hence the skin friction will vary as the ordinate itself, and, referring to Fig. 40, the effective coefficient of skin friction will be greater than normal in the relation of the mean of the ordinates *a b*, *a c* to the ordinate *a d*. Referring again to Fig. 39, it may be observed that the mean pressure increase on the under face is approximately one fourth of the mean pressure decrease on the upper face; taking this proportion as a basis, I give, in Fig. 41, graphs of the augmentation of the skin friction as a function of the aerofoil-pressure constant; the normal coefficient proper to the $L\,V$ value in question being read on the ordinate corresponding to pressure constant = zero, or the left hand of the figure. In the case, for example, of the normal value of the coefficient being 0,008, it will be seen that for a pressure constant = 0.32 the augmented coefficient will be nearly 0.01.

We thus begin to obtain values approaching those that I have found to apply in connection with the theory of least resistance. If, in addition to the above, we allow an addition to represent form resistance, as has been found by Prandtl in the case of the ichthyoid body, and which is due to the degeneration of the stream-line system consequent on the appearance of the frictional wake, we might expect the effective direct resistance of the aerofoil expressed in terms of skin friction equivalent to a coefficient of 0,0175, which is in full and complete agreement with experience. The assumption here is that the proportion of the added form resistance bears the same ratio to the true skin friction, approximately 3:4; as commonly found in the case of the ichthyoid body.

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[89] "Über Längsstabilität der Drachenflugzeuge," 1911.

[90] "Einige Bemerkungen zur Seitenstabilität der Drachenflieger," 1912.

[91] Patent Specification 3608, 1897, or compare also "Aerial Flight," vol. II, page 353.

[92] Compare "Aerial Flight," vol. II, sections 95 to 100, also Bryan, "Stability in Aviation," Chapter vii.

[93] "Sulla stabilità laterali degli aeroplani," also "Perfezionamenti nella stabilità longitudinale degli aeroplani," "Rendiconti delle Esperienze e degli Studi eseguiti nello Stabilimento di Costruzioni Aeronautiche del Genio Anno II."

[94] "Aerial Flight," vol. I, page 389.

[95] Compare the memorandum cited, also addendum to same by Lord Rayleigh.

[96] Ordinarily the linear dimension, represented in the laws of dynamic similarity by L, presupposes geometrical similarity—i. e., geometrical form as an invariable. In the present usage, owing to the thinness of the layer of air effected, L may be taken as the linear dimension of the plane in the direction of motion.

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BEACONS FOR AIRMEN.—[See page 164.]

A New Way of Selling

Manufacturing Cost Plus X Percentage

Several years ago a business organization at Berlin called Zentrale für Weinvertrieb introduced into the retail trade the method of selling "manufacturing cost plus 10 per cent," that is, the firm pledged itself not to charge its customers for the goods purchased more than the actual cost and an additional 10 per cent, which latter was to represent commercial profit. This novel method of selling lifted the veil from the secrets of commercial calculation, which up to then had been carefully guarded, and not only exposed to public gaze the greatest secret of all, the amount of profit, but even gave a pledge to limit this profit in all cases to a fixed minimum. It was, therefore, only natural that the friends of the new method of selling should be drawn from the ranks of the purchasing public, while its opponents, who attacked it with great violence, as the German courts can testify, belonged to the commercial class. There were members of this class who felt their existence to be threatened and who regarded the new way of selling as unfair competition. In commenting on the new method, O. Bechstein says in No. 1287 of *Prometheus:*

"Notwithstanding all opposition, the new method of selling has proved to be full of vitality; it has won adherents in the retail trade, and of late large orders have been given in the manufacturing industry in which the price has been set on the basis of actual cost plus X per cent. So it is possible that, in the course of time, many others engaged in manufactures and commerce will gradually grow more friendly to the new method of selling and will make use of it. Consequently, it is of interest to examine, briefly, whether the general introduction of the new method would be desirable, whether it represents an economic advance, what advantages it possesses over the old method of selling, in which the buyer never learned the profit of the seller, and what are its disadvantages.

"The formula, 'actual cost plus X per cent,' indicates at once that the most important thing for any business based on its principles is to determine correctly the manufacturing cost, its amount and its constituents, which the buyer must have the right of investigating (in the wine business first mentioned, the accounts are examined by an auditing company and any surplus over 10 per cent is returned to the purchasers). This producing cost includes all expenses incurred by the seller in obtaining the commodity and transferring it to the buyer up to the completion of the sale. Consequently, it includes the original purchase price, expense of purchase and of transportation to where the stock is kept, expense of keeping in stock, office expenses, expenses of selling, advertising, packing, dispatching, etc., and, in addition, the indirect charges caused by the loss of interest in granting credit, bad debts, the expenses of collection, etc. In short, the cost of a commodity includes, according to a decision of the Royal Supreme Court, of Berlin, all expenses which the commodity has entailed upon the seller himself up to the actual sale and the receipt of the selling price. The interest upon the business capital, though, is not included in the cost, but is to be met out of the profits of the business, which, therefore, on the basis of cost plus 10 per cent does not amount to 10 per cent but only to the difference between this percentage and the interest on the business capital. The previously mentioned business Zentrale für Weinvertrieb designated, therefore, in my opinion, very correctly the additional 10 per cent as 'turn-over charges,' that is, charges for the work expended in gaining the turn-over, the sale and the obtaining of the commodity, with, in addition, the interest on the necessary capital which the seller must have at his command."

It is easy, with the aid of the explanation of the meaning of cost plus X per cent just given, to prove that the selling method of prime cost plus X per cent represents a real economic advance, because it offers the purchaser the certainty of obtaining a good quality of his commodity at the most favorable price, as it is of much importance to the seller to keep the cost of the commodity as low as possible. Moreover, the seller no longer gains any advantage from debasement or underweight, and, lastly, the ability of the merchant is not only of benefit to himself, as formerly, but automatically benefits the buyer as well.

"At the first glance it might seem that the seller, contrary to what has just been said, would have a direct interest in a high cost, as this more than formerly determines the amount of his profit. This idea, though, is incorrect. The seller, who, in one sale of a commodity, cannot earn more than X per cent, is naturally led to seek this X per cent as often as possible, to strive after the largest sales, in order that the business may yield him the necessary or desired annual profit. It is evident that larger sales can be made at low prices than at high ones, so that in the new method of selling, consequently, the seller, in order to obtain larger sales, is forced far more than by the old method to strive for the lowest possible cost in every way—by favorable purchase, the smallest possible business expenses, great caution in granting credit, the avoidance of keeping goods long in stock, etc.—all of which naturally is of great benefit to the purchaser.

"It is evident that all inducement to adulterate the commodities by admixture of inferior quality, and to deception as to size and weight, must be completely checked by the new method of selling, presupposing, of course, that the buyer can test the calculation of prime cost. The seller would obtain no profit from manipulations to lower the cost, the purchaser would simply buy more cheaply although he would get poorer commodities. If, namely, the seller were to sell 100 liters of spirits of wine, the cost of which might be 150 marks, at a 10 per cent advance, that is at 165 marks, or if he diluted the 100 liters with water until it made 110 liters and then lowered the prime cost of 110 liters to 150 marks, he would never by the sale make more than 10 per cent of 150 marks."

In discussing this topic further, the writer in *Prometheus* says: "Commercial acuteness, which in the new method of selling must naturally have for its aim only the reduction of the prime cost for the purpose of gaining larger sales, as a matter of course benefits the buyer also, for he shares to a large extent in the advantage of a reduced cost. In addition to the advantage he derives from the successes of mercantile skill in business management—reduction of business expenses—the buyer also derives great advantage from the skill of the seller in acquiring the commodity to sell—as in the seller seeking cheaper markets for supply, his favorable purchase contracts, his use of favorable opportunities in the markets for commodities and money, and fortunate speculation. The buyer has, on the other hand, to bear his share in the merchant's mistakes, only, however, when he buys at the increased prices imposed by unlucky speculation and does not prefer to go to competitors who are cheaper because their speculations have been more fortunate. The buyer would be able to do this in the retail trade; he frequently would not have this choice in the wholesale trade and in manufactures."

Looked at as a whole, therefore, the economic advance in the new mode of selling is in this: That the buyer commonly buys more cheaply than by the old method, and that the seller is led to arrange the management of his business so as to combine the utmost energy and economy. In this way the national economy enjoys the advantage of a more favorable intercourse between producer and consumer.

As may be inferred from what has been said, conditions are comparatively simple in the retail trade. At the present time, however, the new method of selling seems about to enter the field of manufacturing, its first entry here being in the ship-building trade, on the one hand in spite of, and on the other probably just because conditions in this trade are much more unfavorable. The Hamburg-American Company has commissioned the Vulcan Company of Bremen to build two new mail steamers. The same principle has been followed for years by the White Star Line. The price to be paid for these Hamburg steamers is not, as formerly, one previously agreed upon, but the shipyard which constructs them is to receive the prime cost plus X per cent.

In ship-building, though, the determining of the prime cost is by no means so easy as in the retail trade, even though this cost may be composed in general of the same items. The small financial success of the large German ship-building yards may be traced in no small degree to the fact that in the calculation of fixed prices large errors may slip into the determining of costs. Many months intervene between the calculation of the cost of a large ship and its completion, during which time, to mention only one point, the prices of necessary building materials can easily undergo large fluctuations. Such fluctuations, when the value of the materials for construction runs into the millions, must result in great differences in the prime costs. Other factors which must be regarded as having a strong influence on the prime cost, and which vary as time passes, are the rate of wages, the condition of the labor market, and the advance in technical methods and organization of business.

"Under these conditions," says the writer in summarizing the question of the new selling method of shipyards, "two cases, therefore, are possible. Either the shipyard adds to the calculation of cost a lump sum for security—and this can only be done to the moderate extent that competition allows—thus making the buyer run the risk of paying too much if it should afterward prove that the additional amount was unnecessary or too high, or else no additional amount is added, or the amount is not made high enough, and the shipyard has the loss. In this case, consequently, both sides would profit by the introduction of the new method of selling, as would also the nation economically.

"The difficulties in determining the costs of work done in a shipyard are so great that the investigation of an auditor would not be sufficient to secure satisfactorily the interest of the buyer; for the whole organization of the shipyard, its working apparatus, the technical ability of its employees, etc., do not come under the survey of a purely mercantile investigation of the books. In this case, the buyer must obtain for himself a survey of the total working of the shipyard by means of his own men who have been trained both technically and in methods of organization. By so doing, he can supervise the correct determining of prime cost, the amount of which is so important to him."

There are unquestionably serious doubts as to the effect upon the independence of a shipyard of such an examination of its internal conditions. At the present moment, it can hardly be settled whether these doubts are so important that, as is assumed in various quarters, they must lead to the direct combination of ship-building with the shipping trade, or whether here, as in retail trade, the cards can be shown, that is, trade secrets can be published, without entailing heavy damage. This, however, could be done in the case of the shipyard by using the principle of prime cost plus X per cent, as in shipyards the financial results could be determined by comparison with previous work, for a large part of the risk of construction could be thrown on the buyer, while he, on the other hand, could protect himself from excessive charges. Experience has shown in retail trade that the principle of prime cost plus X per cent in making sales can be carried out advantageously for seller, buyer, and the national economy. It will also be applicable to many cases in the wholesale trade, and there may be a goodly number of other occupations besides shipyards, among which agriculture would be by no means the last, which could work well and without any great difficulty of organization on the basis of prime cost plus X per cent.

Conditions appear to be favorable for the application of the new principle in the building trade. The great German co-operative supply associations, especially, which incline more and more to develop into associations for production, ought to consider seriously, in the opinion of our author, whether their work would not be more satisfactory if they bought from producers at the rate of prime cost plus X per cent, than if they become producers themselves.

History in Waste Paper

A Contract 2,215 Years Old

A considerable audience assembled at the Royal Society's rooms, in London, recently heard from Mr. J. de M. Johnson a remarkable story of how light is being shed on ancient history through the medium of papyri taken from mummies unearthed in the course of excavations under the auspices of the Egyptian Exploration Fund. The period covered by the discoveries was 1,000 years in the Graeco-Roman era, and the localities were Antinoë and Abydos and the desert region around.

Waste papyri, he explained, was then much used in the process of mummification, and by removing the paint from this by means of acid there had been revealed valuable testimony to the literature and life of the period. Parenthetically, he remarked, the nearest approach we had now to this papyri was papier-maché, but he feared this product would never reveal the secrets of the past. The earliest dated character papyrus discovered was a contract for the sale of wool about 301 B. C. He hoped it would be possible for a series of lectures to be arranged which would reconstruct from papyri some centuries of Egyptian history and life. In some of the graves a considerable quantity of pottery had been found, and one bowl bore the inscription: "Take of the medicine one-sixty fourth part daily."

A number of lantern slides were shown revealing the nature of the country where the excavations are being made, and showing the different methods used in mummification and the varieties of decoration employed. At first, the casings for mummies seemed to have been made for the particular deceased person they inclosed, as appeared from the inscriptions, but, said the lecturer, there were indications that later on they were kept in stock for any purchaser who turned up.—*The Daily Telegraph.*

Telegraphing Pictures

Recently Prof. Arthur Korn read a paper before the Berlin Society of Electricians, on the present state of picture telegraphy, with especial reference to a step relay for strengthening the current employed in the selenium method. The new apparatus for carrying out this system was presented, as was also that for the ordinary telautographic method.

Since the spring of 1907, when the first telegraphic transmission of pictures between München and Berlin by Korn's selenium process took place, ceaseless efforts have been made to perfect not only this, but also the ordinary black and white process. The first is based, as is well known, on the sensitiveness of selenium to light, and its property of varying its electrical resistance with the amount of illumination. A photograph in the form of a transparent film is wound about a glass cylinder, and by the aid of a system of lenses the light of a Nernst lamp is concentrated on one part of the photograph; the light passing through the film is thrown on a selenium cell, which is more or less strongly illuminated, according as the part of the photograph is less or more transparent. When a current from a constant battery is passed through a selenium cell to a distant receiving station, the intensity of the current received will correspond to the light tones of the different places in the original photograph. The sending cylinder is set in rotation, and at every turn is shifted a trifle parallel to its axis, so that all parts of the photograph will be passed through successively by the light rays and the picture will be reproduced at the receiving station. The details of the receiver, the string galvanometer used by Prof. Korn, and the improvement of the process by lessening the inertia of the selenium by the aid of Korn's so-called selenium compensator, have all been described in the technical press.

In 1907-1908, by the aid of this selenium process, many transmissions were made between Berlin and Paris, Paris and London, London and Manchester, Berlin and Copenhagen, Copenhagen and Stockholm; and the *London Daily Mirror* showed very often, in its morning edition, pictures from Manchester and Paris, which would otherwise have come a day later by post.

In these transmissions there was found an undesirable feature: the currents were very weak—at most a milliampère (1/100 ampère)— and for this reason the transmission was often subject to interruptions from side conductors, which were stronger than those for transmitting the picture. The greatest desideratum for picture telegraphy was therefore so to improve the process that the currents would be considerably stronger. While Prof. Korn worked on this problem, he and Prof. Glatzel worked out the telautographic method, using also, at the receiver, the string galvanometer, but at the sender, not the sensitiveness of selenium to light; they went back to a principle 70 years old.

The telautographic method served first only for transmission of writing and drawings; these are transferred in the form of a non-conducting material to metal foil, which is then wrapped about a rotatable cylinder. While the cylinder turns, a fine metal point touches it, and by reason of its regular lengthwise movement touches every part of the subject to be sent, making a fine spiral line over the entire foil sheet. Every time that the point touches a non-conducting part of the sheet (that is a part of the writing or drawing) no electric impulse is sent; whereas, when it passes over a conducting portion between lines or points, a current is sent to the receiving station, enabling the reproduction of the original at the latter place.

This process, as carried out in early times by Bain, Bakewell, Caselli and others, was too slow; but the introduction of the string galvanometer in the receiver by Korn, and the photographic registering, has increased the speed of transmission so greatly that the process is practically useful, not only for the transmission of handwriting and drawings, but also for photographs, which formerly have had to be put into black and white by a Levy screen.

So, recently, there have been very good results obtained between such different places as Berlin and Paris, Paris and London, Paris and Monte Carlo—results often better than with the selenium process. This process can work with currents of 10 to 20 milliampères, and that is the reason why it has been preferred to the selenium system.

It was, however, easy to see that the latter system would come to its own again when it was a matter of great distance between sender and receiver, and especially where the transmission took place through a long submarine cable, which by reason of its so-called capacity does not permit of many impulses per second.

A main condition for the usefulness of the selenium method for this purpose was, that the current could be considerably increased in strength; and now we come to the solution which Korn, with the help of his assistant, St. Carazzolo, has worked out, and which now permits telegraphing photographs to any desired distance, even by submarine cable between Europe and America. The time of transmission is, of course, longer in proportion to the "electric capacity" of the cable, and the transmission is naturally dear; but still it is possible, and can be effected with all desired exactness.

In thus strengthening the current, Korn takes advantage of the property of the sparks of high-frequency currents (the so-called Tesla currents) to light arcs. The weak currents are conducted through a sensitive needle galvanometer, which conducts the high frequency currents to a determined spark section, and every position of the galvanometer needle, that is, every zone of the photograph, creates a strong current arc on the spark section, but only when the weak Tesla sparks arrive. So for every position of the galvanometer, there is only one certain arc; a certain strong current circuit is closed, and with these strong currents all that is desired can be done. One can either send one part of the strong current into the line, or still better, use it for making a perforated strip, which represents the picture, and from which the latter can be transmitted over the line with the speed of transmission permitted by the latter. And finally one can, with the aid of the strong currents which accompany the different tones, send alphabetical telegrams which may be sent like ordinary telegrams and serve to reproduce the picture at the receiving station.

The system permits of application in wireless telegraphy of photographs; it can also serve to show halftone engravings at a distance, by rotating a great number of electric arcs (for instance 100), by using in the transmitter a great number of styluses traveling over the original picture, and suitable weak current relays in the receiver which send the Tesla sparks at the right time to light the electric arcs which are interrupted as long as the Tesla sparks do not reach them.

New Casting Machine

For Making Perfect Pressure and Die Castings

The production of sound castings is often a very difficult matter in the foundry. For some mysterious reason blow-holes will occasionally appear, resulting in the "scrapping," possibly, of many valuable castings and the consequent waste of molders' time. Pressure casting is now coming into use, with the object of securing both castings free from blow-holes and—where die-casting is also adopted—castings of good surface, since they have not been in the sand.

Just how the pressure on the molten metal—obtained from a hydraulic press, gas pressure, or liquid pressure due to a head of metal—acts in the direction of securing castings free from blow-holes is a question that is still being debated. The probability is that since pressure facilitates the solution of gases, the gas, which, left to itself in the metal, would cause blow-holes, is caused by the application of pressure to be retained in solution and to occupy only an infinitesimal part of the space it would normally occupy in the molten material, so that when solidification takes place the cavities left are so insignificant as to be of no practical importance. It has been shown by Sexton that under the pressure of ten tons per square inch, which is often exceeded when steel is cast under hydraulic pressure, any separated gas bubbles in the molten metal would be diminished to about 1/3,000 of their normal volume. This fact certainly indicates a very valuable attribute of pressure casting, a system now applied to metals other than iron and steel.

Particularly is this the case with alloys such as Babbitt's metal and zinc and aluminium alloys, all of which lend themselves not only to pressure casting, but also to casting in dies.

A distinctly novel form of automatic pressure die-casting machine, which appears to open a new field in the direction of rapid and clean casting, has just been perfected by an English firm of engineers. Forming the base of this machine there is a furnace containing the necessary crucible to carry the molten metal. Bolted to this is a neck-piece, on top of which is fixed a domed cover, near the center of which is formed a pocket, having screwed into it a circular block of specially hard metal, bored out to form a taper nozzle, and slotted to take the sprue cutting bar. In this pocket and around the taper nozzle is a small furnace which keeps the metal perfectly molten, right up to the time of entering the die. Held in place by means of a gland and stuffing-box on the underside of the nozzle is a tube of refractory material, which passes down through the molten metal to within about half an inch from the bottom of the crucible. Through a gland in the domed cover a spindle runs down into the crucible, carrying two perforated disks, which are plunged up and down in the molten metal by means of a hand lever, thus keeping the metal well agitated. A hole and cover for same is also placed in the domed cover to allow of the crucible being filled without removing the cover. Hinged to the domed cover is a plate, to which is fixed the bottom half of the die from which the casting is to be made, and having in the center a hole to register exactly with the nozzle before mentioned in the circular block of hard metal, and also with the filling hole in the bottom half of the die. The hinged plate referred to is tilted back into any desired position by means of a suitable bevel and worm gear. Screwed into the hinged plate are three bright mild steel pillars carrying a bridge piece through the center of which works a double-threaded quick running screw, operated by a heavy hand-wheel or cross-bar at the top and carrying at the other end a plate registering on the three bright pillars. This plate carries the top half of the die. The domed cover, together with the center tube agitating disks and all the top gear, are capable of being thrown back by means of a worm gear, thus allowing of ready access to the crucible.

The process of casting is as follows: The metal to be melted is placed in the crucible through the filling-hole before described. The furnace is lighted, the bottom half of the die is fixed to the hinged plate, and the top half of the die is fixed to a plate carried by the quick-running screw. This is now run down so that the top and bottom halves of the die are brought tightly together. Here we may say that when it is necessary to use a multiple part die, a convenient detachable arrangement is provided to work horizontally in conjunction with the vertical clamping arrangement already mentioned. The sprue cutting bar is put into position so that the molten metal cannot pass through the nozzle, and the hinged plate is clamped, down. Connected to the neck-piece is a cylinder of liquefied gas, the valve controlling which is now opened, allowing the gas to exert pressure on the top of the molten metal in the crucible. The sprue cutting bar is now pulled back, thereby allowing the metal to be forced up into the die. The die being full, the sprue cutting bar is pulled back again, thereby stopping any further flow of metal, the hinged plate is unclamped, and the whole of the top gear thrown back, by means of the bevel and worm gear, onto a suitable table; the top half of the die is now pulled up by means of the screw, and the casting is automatically knocked out of same by means of three rods carried on a bridge piece and which run into the top half of the die nearly down to the casting when the two halves of the die are together. The whole top gear is now thrown back, the hinged plate is clamped down, the two halves of the die are brought together again, and the sprue cutting bar (out of which the small piece of metal, cut away, has been punched by means of a lever punch carried on a hinged plate) is again put into position to allow the metal to flow into the die, and the process is continuously carried on as described. It will be noticed that the dies are kept at the most suitable temperature for casting, owing to their being directly in conjunction with the small furnace, while at the same time no flames come into direct contact with the metal, thus avoiding oxidation.

Great pressure can be exerted on the molten metal, as when the liquefied gas is brought into contact with a hot substance the expansion is such that, at a temperature of only 15 deg. Cent., a pressure of 100 atmospheres is obtained, and proportionately higher pressures can be maintained according to the various temperatures worked at. The gas used is an inert one, and therefore has no action on the metal; neither is it absorbed by the metal.

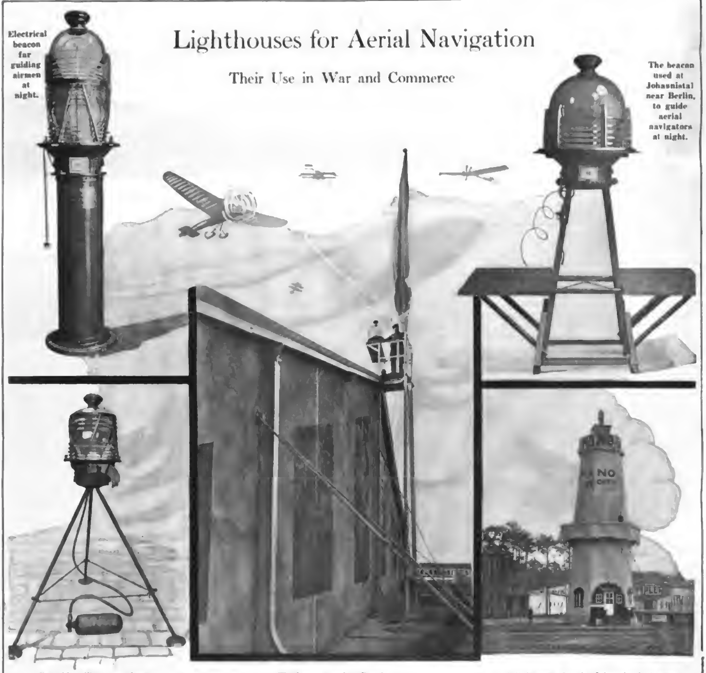
The machine would appear to be far in advance of anything that has yet been made for die-casting, and though it will take dies up to 9 inches square, machines to take dies considerably larger are being designed. Comparatively few machines have been brought out to deal with alloys containing a large percentage of pure aluminium, owing to the fact that aluminium attacks wrought iron or steel when molten, and also shrinks and cracks during the process of solidification in the die. The dies for the above machines have received special consideration, as it has been difficult in the past to design a die which did not produce porous castings or form air locks when used in connection with alloys containing a large percentage of aluminium.—*The Daily Telegraph.*

Refractive Index of Radium Emanations

A. W. Porter and C. Culbertson describe in the *Journal* of the Radium Society experiments made to determine the refractive index of radium emanations. The difficulties lay in the small quantity of gas available (1/10 millimeter^3) and the difficulty of keeping the gas pure. A specially designed Fabry-Perot interferometer was used. The vessel into which the emanation was introduced had two plane-parallel faces (distance apart, e), partly silvered in the insides. The ordinary Fabry-Perot fringes were obtained with a vacuum between the plates, the emanation was then introduced and the refractivity determined from the number n of bright bands which passed over a fixed point in the observing telescope, i. e., $\mu - 1 = n\lambda/2e$. Owing to the difficulty of working with the pure emanation and to the limited supply available, no definite values have so far been obtained, but the results show that the refractivity of the emanation is higher than that of any other known gas and at least twenty-five times that of helium. From certain theoretical considerations of the ratios between the refractivities of the inert gases the authors conclude that the value ought to be about forty times that of He.

Lighthouses for Aerial Navigation

Their Use in War and Commerce



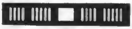
Electrical beacon far guiding airmen at night.

The beacon used at Johannisthal near Berlin, to guide aerial navigators at night.

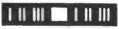
Portable military gas beacon.

The beacon used at Potsdam.

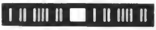
A lighthouse for the Johannisthal airmen.



Light signal known as mark 45.



Light signal known as mark 123.



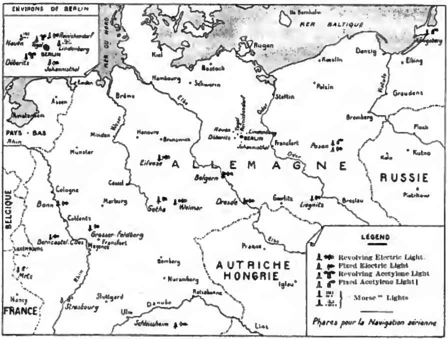
Light signal known as mark 1242.

To be of real use in war, aeroplanes will have to be flown at night. Their pilots would, in this way, be at the right spot for a reconnaissance by daybreak, or, in cases where the hostile troops are protected by day from aerial investigation, the pilots would be able by night flying to judge the contour and arrangement of a camp from the bivouac fires and lights. Even in times of peace, night flying will become necessary to those who wish to make long flights in a limited space of time. Night flying, though, either for warlike or peaceful ends, requires practice. In order to make such flights possible, in the opinion of Raoul Volens, who writes in *Aerophile*, the main routes of the air must be marked out, so that the aviator may know at any moment where he is, where he can land, and what obstacles he may meet. France, says our author, has done nothing in the matter, but Germany has been working on the problem for over a year. Her aim is to enable her military aeroplanes and dirigibles to start and land at night on all the aerodromes of either her eastern or western frontier, and to transfer her aerial forces quickly from one frontier to the other at will. To this end she is using what may be called lighthouses and beacons on her frontiers and connecting routes. There are twenty-one such lights already, generally at sheds for dirigibles and aeroplanes, which have been located with the same strategic end in view. The lights are of different kinds. The very powerful ones, the real aerial lighthouses, are to aid the aviator to find out where he is. Lesser ones are to point out the dangers he could not know beforehand, for by night a pilot can see vaguely the main outlines of the landscape, but he could not see until too late a very high tower or an electric wire. A third class of still weaker beacons are to aid in making a landing. In Germany the light was first thrown toward the heavens in a cone with a vertical axis and a small angle at the summit. It turned out that these lights could not be seen unless close by, and a beacon ought to be seen at a long distance. Flying at night is not done at a very great height, probably at not more than 500 to 800 meters above ground. The axis of the pencil of rays should, therefore, be very slightly inclined toward the horizontal, ascending in most cases, and descending only when the light is set on a high mountain. The intensity of the rays should decrease from the horizontal toward the vertical, where it should merely be sufficient to be seen from an aeroplane flying at 4,000 meters.

Another difficulty to be solved was the identification of these beacons. This could not be done with colored glass, as such glass absorbs a large amount of light, except for landing lights. For most of the other beacons, following the example of marine lighthouses, fixed, revolving and flash lights have been adopted, while still another class is arranged to throw a series of flashes of greater or less length, thus transmitting Morse signals. These last mentioned lights are called "Morse beacons."

The only lights of peculiar construction are the landing beacons. Those constructed by the Pintsch Company are intended to show the aviator in what direction he should land. They are sunk in the ground of the aerodrome and covered with a thick glass on which the aeroplane can alight and run. Their arrangement is the following:

A large white light 1 meter square is set in the center of the aerodrome. At 80 meters from this, following the points of the compass, there are four red lights which are connected by a subterranean channel to a series of contacts worked by a vane. When the beacon is in use only the central white light and one or two of the red lights are in action. Should the wind be north the red light to the north of the white light burns; if the wind comes from the northwest, the red lights to the north and west are lighted. When the vane turns, the red lights which no longer correspond to the direc-



Map giving locations of aero lighthouses and beacons existing April 1st, 1914.

tion of the wind are extinguished and are replaced by the light or lights which agree with the new position of the vane. When there is no wind at all only the central white light is visible. The aviator is thus instructed as to the direction of the wind near the earth and can maneuver so as to land facing the wind, or when the wind is negligible at the ground he is also notified of this fact.

The accompanying map from the *Aerophile* shows the aerial lighthouses and beacons existing in Germany on April 1st, 1914, and indicates the characteristics of these lights. According to our authority there are twenty-one of them, as follows:

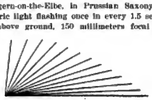


Diagram illustrating direction and relative intensity of rays of light employed.

1. Belgern-on-the-Elbe, in Prussian Saxony: revolving electric light flashing once in every 1.5 seconds, 72 meters above ground, 150 millimeters focal distance, 7,000 candle-power; gives warning of high-tension cables, and is in course of construction. 2. Bernkastel-Kues: revolving electric light giving two flashes, 425 meters above sea level, 150 millimeters focal distance, 250,000 candle-power; opened in March, and shows where aerodrome is. 3. Bonn: fixed electric light with Fresnel lens or circular disk of stepped prisms, 25 meters above ground, 8,500 candle-power; gives by series of flashes the number of the station; belongs to the municipality. 4. Döberitz: revolving acetylene light flashing every 3 seconds, 50 meters above ground, 250 millimeters focal distance, 27,000 candle-power; belongs to the military aerodrome, and is soon to be lighted by electricity with much higher candle-power. 5. Kaditz, near Dresden: revolving electric light with two flashes in 9 seconds, 46 meters above ground, 250 millimeters focal distance, 250,000 candle-power; shows the aerodrome at Kaditz. 6. Eilvese, near Neustadt, in Hanover: wireless station; revolving electric light flashing every 4 seconds, 22 meters above ground, 800,000 candle-power; indicates the tower of the T. S. F. station. 7. Gotha: fixed electric light with Fresnel lens, 22 meters above ground, 30,000 candle-power; indicates by flashes the number of the station; belongs to the Gotha carriage factory. 8. Grosser Feldberg, in the Taunus Mountains: fixed electric light, 910 meters above sea level, 800,000 candle-power, which will be raised much higher; was to be opened in April. 9. Johannisthal, near Berlin: fixed electric light with Fresnel lens, 25 meters above ground, 30,000 candle-power, indicates by flashes the number of the station; only used when required. 10. Königsberg: fixed acetylene flash light with Fresnel lens, 15 meters above ground, 1,300 candle-power; belongs to the military authorities, and indicates the shed for dirigibles. 11. Liegnitz: fixed electric light with Fresnel lens, 30 meters above ground, 8,500 candle-power; flashes give the number of the station; belongs to the military authorities, and indicates the shed for dirigibles. 12. Lindenberg, near Berlin: Morse beacon of nine lamps with metal filaments having together 3,600 candle-power, 130 meters above sea level; gives by flashes the letter L, at the Lindenberg Meteorological Observatory. 13. Metz: fixed acetylene flash light, Fresnel lens, 30 meters above ground, 1,200 candle-power; belongs to the military authorities, and indicates the dirigible shed. 14. Nauen: wireless station; Morse beacon with filament lamp of 1,000 candle-power, 180 meters above ground; gives letter N in flashes; shows large tower of the T. S. F. 15. Posen: fixed acetylene flash light, Fresnel lens, 15 meters above ground, 1,800 candle-power; belongs to the military authorities, and is on the field for maneuvers. 16. Posen: fixed electric light, Fresnel lens, 30 meters above ground, 8,500 candle-power; flashes give number of the station; belongs to the military authorities, is at the Wimarg shed for dirigibles. 17. Berlin, at Reinickendorf, fixed electric flash light, Fresnel lens, 30 meters above ground, 1,200 candle-power; belongs to the military authorities. 18. Schleissheim, near Munich: fixed flash light, 2,500 candle-power, can be raised to 30 meters above ground; belongs to the military authorities. 19. Strasburg: fixed acetylene light, Fresnel lens, 2,500 candle-power; flashes give number of station; at the aerodrome, and belongs to the military authorities. 20. Tegel, near Berlin: revolving acetylene flash light, 50 meters above sea level, 150 millimeters focal distance, 2,000 candle-power; belongs to the Second Battalion of the Aviation Corps. 21. Weimar: revolving electric flash light, 15 meters above the aerodrome, 27,200,000 candle-power; placed at the disposal of the Aviation Society of Weimar by its owner, the Carl Zeiss Company of Jena; works when required.

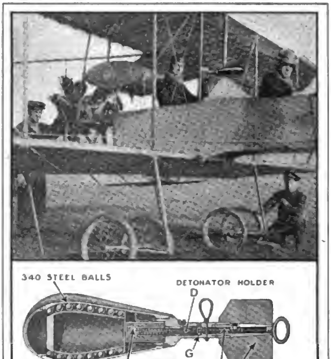
An Aeroplane Bomb That Explodes Only on Striking the Ground

THE new Marten-Hale aeroplane bomb, recently tested in England, has a very simple priming mechanism so that it can be carried in a magazine on board an aeroplane without danger of accidental explosion. Should a bomb be hit while the aeroplane is in flight, or in case the aeroplane descended violently to the ground, by accident or otherwise, it is impossible for an explosion to take place. The bomb can explode only upon making a certain fall through the air and then striking the ground or other obstacle.

At the top the bomb has a tail piece *C*, rotatable by the air vanes. The detonator holder *D* is held up away from the main charge by means of its collar, and ball-bearing *G* held in place by the projecting end of a screw releasing spindle *H*. When the bomb drops and the spindle rotates, through the action of the vanes, it is screwed up until the projection moves away from the steel balls and allows them to fall inward, thus releasing the collar and the detonator. But the detonator still remains off the charge through the spring. When the bomb hits the ground, the detonator falls down on the charge and fires it, exploding the bomb in the customary way. Such bombs can be dropped simply by hand from the aeroplane or fired by a spring gun.

We illustrate a bomb of the shrapnel type, which has a total weight of 20 pounds and carries an explosive charge of about four pounds of trinitrotoluol. It has 340 steel balls, which weigh 5 pounds 12 ounces.

A drop through at least 200 feet in the air is needed in order to cause the rotation of the tail end sufficient to give the release and arm the bomb as we have just seen, and as the firing mechanism is very sensitive, it gives an explosion upon the least impact, even on water, mud, snow or the envelope of an airship. The angle of incidence can be as low as five degrees, as it is found. It is found that when dropped in any position from the aeroplane or at any speed of flight, the projectile soon takes the vertical position in falling, so as to hit the ground quite straight and end-on, and there is no tendency to somersaulting or wabbling in the air.



An aeroplane bomb that explodes only when it hits the ground.

Electric Mine Gas Detectors[*]

Different Devices that Have Been Used or Suggested to Test for Gas with an Electric Lamp

By Sydney F. Walker

THE ordinary oil-burning safety lamp performs a double office in coal mines. It furnishes light, and it denotes the presence of firedamp. Although the portable electric miner's lamp will not detect methane, it is safer than the ordinary gauze safety lamp; it is not so easily extinguished, and it furnishes considerably more light. The fact that the electric lamp will not detect gas is a disadvantage; nevertheless that has not prevented its adoption. In British mines some years back portable electric lamps were very common, although not as strong nor as light as the Hirsch and Hubbell lamps; but at Murton colliery, Durham, England, some 2,000 Sussmann portable electric lamps have been in use for about fifteen years. Since the series of explosions that have occurred in coal mines in the United Kingdom within the last five or six years, several of which have been suspected to be caused by the old form of safety lamp, there has been a strong tendency toward the use of electric lamps. The difficulty of the detection of gas is met by the provision of a certain number of safety lamps, by which gas can be detected. Firemen carry an electric lamp, and an oil-burning lamp for testing.

The essential feature which provides the safety of the electric lamp, the inclosure of the heated filament within a globe from which the air has been exhausted, the globe being protected by a stout glass similar to those used in the oil-burning safety lamps, precludes the filament itself being used in any way as an indicator of gas. In the electric lamps which have passed the Home Office, and which were awarded prizes in a competition which took place two years ago, every effort is made to cut off the current from the filament in case of any accident happening to the lamp. In the best of the lamps the incandescent globe itself is placed between two springs, one of which makes connection with the battery; and anything which would cause a breakage of the lamp globe immediately severs the connection, long before the gas could find its way to the filament.

Anything, therefore, which indicates gas must be external to the lamp globe, and several attempts have been made to work out something of the kind. Up to the present there is no satisfactory electric gas detector upon the market. Inventors, so far, have worked along two lines. One inventor produced a gas detector that could be used by firemen, in which the difference in the rate of the diffusion of methane and ordinary atmospheric air, through a porous diaphragm, was made to operate an electric contact, closing an electric circuit and lighting a small lamp that was colored red. As far as the writer is aware, this apparatus never went beyond the testing stage; but with the enormous developments that have taken place in connection with electric lamps it is well worth any inventor's while to take up the subject on those lines. Another apparatus, designed upon something of the same lines, but smaller and more portable, is arranged to be either carried in the pocket or attached to a lamp. A U tube in which is a mercury column indicates the percentage of gas, and the instrument, it is stated, can be employed to detect CH_4 or CO_2.

Turquand's apparatus for testing for gas in mines consists of the U tube shown in Fig. 1, the ends of which pass into slots in a metal block. The ends of the U tube are open, but the slots are closed by porous stoppers *a*, thus leaving a space *b* between each end of the U tube and each porous stopper. In one space a palladium wire *c* is fixed, through which a current can be passed, either from the battery attached to the lamp or from an independent battery. In the other space an absorbent has to be placed, so as to discriminate between CH_4 and CO_2. The U tube has a very fine bore, and in it is what the inventor terms a thread of mercury. Normally the mercury will be at the same level in the two legs. When a gas having catalytic value that will act upon the hot palladium wire in the well-known manner, passes into the catalytic space, heat is liberated, and the thread of the mercury is pushed down one leg and up the other. The U tubes are graduated, presumably in units, showing the percentage of gas. Fig. 2 shows the connections for supplying current when the apparatus is in use.

Almost all other methods that have been employed depended upon the contact action between firedamp and a platinum wire, that is, when a combustible gas is brought in contact with a platinum wire and causes it to glow. The earliest apparatus, that of Prof. Liveing, employed two platinum spirals, glowing equally, one in atmospheric air, and the other in the gaseous atmosphere to be tested. The percentage of gas was found by comparing the light given by the two spirals on a photometer scale. It was used some in English mines, but only by managers and others who possessed the necessary skill and patience. Sir Joseph Swan, soon after his incandescent lamp was perfected, introduced an attachment in which a column of mercury, which expanded under the heat liberated by the catalysis of the platinum wire, showed the percentage of gas upon a graduated scale.

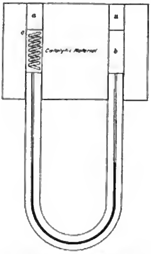


Fig. 1.—Turquand's gas testing apparatus.

Some fourteen years ago, when the Sussmann portable electric lamp was introduced into the Murton and one or two other collieries in Durham, an attempt was made to attach an indicator to the lamp. This was constructed along the same lines as Sir Joseph Swan's, but the mercury bulb was covered with spongy platinum, and the action of the carbureted hydrogen gas upon the spongy mass caused a rise of temperature, which was recorded by a column of mercury moving over a graduated scale. The Sussmann lamp unfortunately was not successful, commercially, though a very large number were employed on the Continent and in the United Kingdom.

Messrs. J. H. Holmes & Co., electrical engineers of Newcastle, brought out a gas detector about four years ago that was intended to be fixed at different places in the mine, and to ring a bell in the overman's cabin, or on the surface, when gas appeared in certain prearranged quantities in the neighborhood of the apparatus. In this apparatus also, a column of mercury moving over a graduated scale closed an electric contact; the bulb of the thermometer, as it was practically, being inclosed in spongy platinum. About three years ago the problem was taken up by Mr. George Ralph, and the writer, on behalf of Sir William Garforth. In Mr. Ralph's apparatus a simple arrangement known as the differential galvanometer was employed. The galvanometer is an apparatus in which a current passing in a coil of wire surrounding a magnetic needle causes a deflection of the needle, bearing a certain relation to the current. In the differential galvanometer there are two such coils acting in opposite directions upon the needle. Under ordinary conditions the needle is stationary; but if the current passing in one coil is greater than that in the other, the needle deflects. The current in one coil may be lessened by an increase in the electrical resistance of the circuit in which that coil is included, and this was the method adopted by Mr. Ralph. One of the coils of the differential galvanometer included in this circuit a platinum wire which was arranged to be exposed to the gas, protected by the usual gauze. When gas was present, catalytic action took place in the platinum wire, the resistance of the wire increased in a certain ratio to the amount of gas present, and the needle deflected. Variations of Mr. Ralph's method included an apparatus for extinguishing the light given by the lamp, for putting a buzzer in action and other arrangements. Unfortunately all the experiments mentioned, with the exception of those of Prof. Liveing and Sir Joseph Swan, were made with ordinary illuminating gas. It was supposed by all those who were working at the problem that town gas and mine gas were the same. In the United Kingdom, however, town gas contains about 40 per cent of hydrogen and only about 35 per cent of methane; while mine gas consists almost entirely of methane. Hydrogen gas has a very much more energetic catalytic action upon a glowing platinum wire or spongy platinum than methane; and it was found that the apparatus that gave excellent results with town gas, showing a fraction of 1 per cent gas, gave absolutely no indications when taken into a colliery and tested in positions where it was known that methane was present.

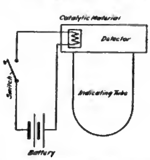


Fig. 2.—Electrical connections of the gas detector.

The apparatus constructed for Sir William Garforth was on totally different lines. Mr. Garforth had invented an apparatus for testing for gas with the ordinary safety lamp, in which a rubber bulb having a strong metal nozzle was used. In the base of the oil-burning safety lamp was a tube and a self-closing valve. When testing for gas the bulb was placed in one of the cavities in the roof where gas was suspected, squeezed in the usual way, a bulb full of the atmosphere taken, a finger placed over the nozzle, the lamp taken to a safe position, the nozzle pushed through the base of the lamp, opening the valve in the process, and the gas in the bulb was squirted over the flame in the lamp. It will be seen that this method enabled tests of gas to be taken easily and quickly under conditions where it was almost impossible by the ordinary method, of nearly extinguishing the light, and pushing the lamp up into a cavity in the roof.

In the apparatus there were one or more small glass tubes fixed inside of the usual protecting glass tube of the portable electric lamp. Each of the small glass tubes held a platinum wire of a gage varying with the quantity of gas that was suspected. At the entrance to each tube was a self-closing valve that was pushed open by the nozzle of the rubber ball described above. It switched on the current to the platinum wire, and it opened the way for the gas to pass to the wire. In using the apparatus the nozzle of the bulb was first pushed into the aperture, opening the valve, and time was given to allow the platinum wire to come to its proper temperature. The gas was then squeezed from the bulb over the wire. The little test tubes were arranged to be easily and quickly replaced, and the platinum wire was protected by gauze in a similar manner, though on a small scale, to that in which the ordinary oil-burning safety lamp is protected.

The writer, with his client's full knowledge, worked with ordinary town illuminating gas, and with that he produced detector tubes of sufficient sensitiveness to show the presence of 0.5 per cent gas. It was his intention to have gone on from that point with pure methane, and he proposed to have used the metal palladium, which is more sensitive than platinum; and the measurements which he made upon an experimental tube in which a palladium wire was employed showed that there was every probability of obtaining as great success with palladium and methane as he had obtained with platinum and ordinary town gas, but his client would not go on. In the apparatus worked out for Sir William Garforth it was arranged to carry one, two, or three tubes in any lamp, and there was a range of tubes with corresponding platinum wires, all of the same length, but of varying section, so that tests from 0.5 per cent up to 5 per cent could be obtained. The method to be adopted was, the lamp man would carry tubes in his pocket and would make tests downward. He would put in the coarser tube first, then tubes with finer wires, and so on.

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[*] From the Colliery Engineer.

Navigation Without Logarithms*

By Walter D. Robinson

Capt. Guyou of the French navy, a mathematician of note, author of valuable works dealing with the problems of navigation, and member of various learned societies, has devoted part of his time since his retirement to producing tables from which a "line of position" (Sumner line) can be worked and the ship's position thereon approximately determined with the least labor and in shortest time.

The tables are preceded by a condensed explanation for the benefit of those who wish to understand their mathematical development; but the many practical and efficient navigators who bother little with theory will be interested to know what Capt. Guyou does, without having to concern themselves as to how he does it.

Gird up your imagination and conceive the world and the heavenly bodies as standing still: suppose, further, that your ship is connected with a heavenly body not directly overhead—the sun, for instance—by a steel rod having a universal bearing where attached to the ship and another where attached to the sun. Start up your engine and let the wheel alone! The ship will be so controlled by the rod that she must describe an enormous circle on the face of the waters, having for its center that point on the earth's surface at which the sun is then in the zenith. Meanwhile, the rod describes an enormous cone with the sun at the apex, and when we consider that the sun's altitude, or height, is measured by the angle inclosed between the rod and the base of the cone (roughly), we can realize that an observer on board, taking the sun's height with a sextant at frequent intervals, will get the same height all the way around the circle.

The foregoing must be qualified in practice because the world does not stand still and the ship is not going to sail on a circular course; true, she is on the circumference at the moment of observation, but she may be crossing it at any angle because the position of the center of the circle and the direction in which the circumference trends depend upon the sun and not upon the ship.

If the ship be at rest, the observed altitude of the sun will change continually from hour to hour because of the apparent motion of the sun in his diurnal course. If the ship be in motion, the observed altitude of the sun will likewise change from hour to hour, not only because of the sun's apparent diurnal motion, but also, although by a comparatively small amount, because of the fact that the ship is under way pursuing a certain course and making a certain rate of speed. It is evident that she may be considered to be crossing a circumference at any moment and that all sun observations *taken at that moment* from ships on different parts of that circumference will show the same altitude.

Two problems present themselves!

First: To find the circumference.

Second: To find the point at which the ship was crossing it when the observation was taken.

They have been dealt with in various ways. An able French admiral, Marcq de Saint-Hilaire, evolved an admirable solution by working out the distance from the dead-reckoning point—almost always more or less erroneous—to the circumference; his method may be outlined as follows: The navigator measures the height with a sextant, notes the time, then *calculates* the height he would have gotten at the dead-reckoning point at the moment of observation. If the two heights agree the dead reckoning may be accepted as correct, for it coincides with the circumference; this occurs but rarely; as a usual thing the dead-reckoning point falls several minutes (of distance) outside the circle or within it, two heights result, and the difference between them enables the navigator to work out the error in distance from dead reckoning to circumference. This solves the first problem!

The solution of the second is simpler, because the dead reckoning is sufficiently reliable to limit to a few sea-miles that portion of the circumference at some point in which the observation must have been taken. Since the circle is very large, this small portion of circumference may be accepted as a straight line. It is the navigator's "line of position" and the ship's crossing point thereon is closely approximated by the direction of the center of the circle from the dead-reckoning point, which direction, since the sun is the zenith of the circle's center, is rendered by the azimuth.

But this method, though far the most desirable theoretically, involves the danger of error, the time, labor, and irritation inseparable from an appalling array of logarithms—I rejoice that I am not called upon to express the sentiments with which a tired and hungry man in oil skins regards logarithms—the calculation of height at the dead reckoning point calls for a half dozen, the azimuth for three or four more, and these operations are followed by an excursion into trigonometry to localize the result; which result, if you are an amateur, will doubtless be wrong, while, if a professional, you will not have tried it.

With Capt. Guyou's tables one enters with true height and declination in a page devoted to the approximate latitude and takes out two numbers, turns to a page devoted to the approximate hour-angle and takes out two more. With these numbers he does one small sum in addition and two in subtraction, then rules off the ship's position on the chart.

One can only admire the lofty unconcern with which Capt. Guyou juggles distances, especially as he juggles them accurately. One of his circles can inclose the greater part of a hemisphere, but he does not hesitate to slide it down until the dead-reckoning latitude coincides with the equator, where he performs his mathematical feat with the two heights before coolly sliding the circle back again. Of course the objection at once arises that the navigator would not have gotten the same observed and calculated heights on the equator that he did get in higher latitudes, but here Capt. Guyou's versatile resource comes into play, for the navigator *would* have gotten the same number of minutes of difference between the two heights (expressed in minutes of the respective latitudes). This difference, as we have seen above, yields the error in distance between dead reckoning and circumference, and from it, in connection with the azimuth, the position can be worked out.

But Capt. Guyou does not slide down to the equator merely in search of the above-mentioned error. He has another purpose and it is indeed ingeniously accomplished: we all know that the basis of navigation is the spherical triangle, and that three parts of it—two sides and one angle, for instance—must be known before it can be solved. But tables calling for the combination of three known quantities throughout the extent of 90 degrees of latitude and 360 degrees of longitude would be ponderous and impractical. With only two known quantities these objections do not obtain, but two known quantities do not suffice to solve the problem. In drawing up his tables Capt. Guyou has used three, of which the latitude is the third, and has employed a trigonometrical formula in which the required result is obtained by multiplying functions of the two other known quantities by the tangent of one half the complement of the third (the latitude). Since he has slid his circle down until the (dead reckoning) latitude coincides with the equator his latitude is 0 degree; the complement 90 degrees; and the tangent ½ 90 degrees = 1, which, as a multiplier, may be disregarded, thus reducing the known quantities which must be considered to two, and rendering the tables practicable.

Little knowledge of navigation is required in using them. One must understand reducing observed height to true and correcting the declination for the moment of observation. It is of course necessary to be familiar with the varieties of time used at sea. In figuring, one must know, and observe, the diffence between + and —.

These moderate requirements can be mastered in a few evenings, and practice may then be begun over an artificial horizon, or otherwise, for the tables include a page of directions which cover all cases, and can be blindly followed to a correct result. A general conception of the principles of navigation and the problems involved will come with practice and the necessity of thinking out one's mistakes, and, in a short time, a new hand should be able to work at sight with confidence and accuracy.

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* "Nouvelles Tables de Navigation," Émile Guyou. Berger Levrault, Éditeurs, Paris. Review from *Science*.

Man's Chin

A Dynamical Basis for Physical and Psycho-Physiological Utilities.

To account for the presence of man's chin at least three different explanations have been brought forward and discussed: (1) That the chin has been evolved by sex selection for its esthetic value; (2) that it was needful for the development of the genio-glossal muscle and speech; (3) that with man's erect posture the chin has been chiefly useful in affording room for important structures in the throat, and in protecting them during combat, etc. These explanations have so far met with very little acceptance.

A conception of the chin as a *dynamical* factor in both mastication and speech does not appear to have received attention. An engineer examining the dental mechanism as a type of machine new to him would, on finding there was a considerable bulk of constructional material projecting from the chief moving member, be nearly certain to ask—What does this do? The chin mass is situated at the outer end of the jaw lever, where its momentum is greatest. It is built up in the heavier material used in the general construction. There is another point, too, that one should not too readily dismiss as a mere coincidence. Every rotation movement of the mandible during its elevation or shutting has combined with it a movement—obliquely upward and backward—of translation. The combined movements are so directed that at some parts of the jaw the resultant velocity is less than would exist if either component were to act alone; and at about a point situated between the jaw angle and the condyle, the resultant velocity is so small that some observers mistakenly believed it to be nil. At the chin, on the other hand, the directions of the component movements are such that the resultant velocity reaches nearly its maximum acceleration.

My suggestion is not quite that the chin is simply man's masticating hammer; something rather less crude than a purely percussive function is conditioned by the momentum of the chin. No doubt the momentum of the chin may appear to be a very small contribution to the considerable muscular force often used in chewing. Yet on the teeth themselves many morphological details that have been preserved as distinct specific features are so small that we do not yet know what the particular utilities are that determined their shape and survival. Further, there is another peculiarity in the mandible movement that may have some significance in this connection. During a (supposable) uniform movement of rotation about the condyle as horizontal axis, the accompanying translation movement is not uniform, but relatively varied—slow or small in the beginning, quicker in the middle, and slower again toward the end of the condyle path. This is favorable to the normal *rhythmical* movement of the jaw by giving in some degree a pendulum-like character to its swing. And it so happens that the position of maximum velocity (and momentum) coincides with the position of greatest resistance and food-strain in chewing—that is, when the cutting-edges of the external blades of the lower cheek teeth are just about to pass their upper opponents in the inward-and-upward shearing thrust. The chin momentum operates most strongly just about the point where it is most useful in preserving the rhythmical movement of mastication, so as to render less necessary any *consciously* directed variation in the muscular effort put forth in any single chewing stroke.

Then, in the numerous smaller chewing movements for the finer reduction of food morsels, the chin mass (by both inertia and momentum) has at least some value as a "balance"; controlling and guiding the niceties of direction in the thrust. The utility of balance influences the construction of many man-made implements (pen- or brush-holder, razor handle, spear, etc.) in the use of which some precision is required; this feature in construction has usually been adopted, and has survived quite independently of any conscious or theoretical estimation of its special function. The obvious objection that animals manage the "niceties" of mastication without a chin could be met only by going more fully into the dynamics of the subject. This much at least can be stated here as being susceptible of proof—that as compared with the prognathous savage or the ape, the dental apparatus of modern civilized man is the "finer" machine, in so far as it is the better adapted for those shearing stresses by which tough foodstuffs are comminuted with economy of effort.

The above suggestion of "balancing" and "steadying" utilities can also be applied to the rapid and yet delicately controlled movements of the mandible in speech. The man who wrote a book on "The Speech of Monkeys" might possibly have had hope of more success in interpreting the "language" of these animals if only he could have subdued and steadied their jibberings and chatterings by providing them with good weighty chins.—From a letter to *Nature* by D. M. Shaw.

The Melting and Solidifying Points of Lava

An account is given in the *Proceedings* of the Mathematico-Physical Society Tokyo, by K. Fuji and T. Mizoguchi, of some investigations in relation to the above subject. By an apparatus designed to give simultaneously both the temperature and electrical conductivity of lava, a range of temperatures was obtained over which lava is melting and solidifying, on the assumption that the electrical conductivity of the molten lava increases proportionately with the decrease of viscosity. A curve in which current, representing conductivity, is plotted against temperature shows a point of inflection at about 1,150 deg. Cent., which the authors consider would correspond to the melting point of a crystalline substance. The values given of the specific resistance at various temperatures are, in the neighborhood of the melting point, somewhat less than that of sea water. The importance of this high conductivity in connection with its influence upon the propagation of Hertzian waves is pointed out. The results of the melting-point determinations are compared with observations made by one of the authors upon a lava stream from a volcano by means of a Holborn-Kurlbaum optical pyrometer. The results show that the optical pyrometer cannot be relied upon for such measurements.

Applications of the Coolidge X-Ray Tube*

Illustrating the Varied Subjects that are Within the Range of a Single, Simple Tube

By Dr. Wheeler P. Davey

There have lately been published many very interesting radiographs of flowers, leaves and insects. Typical instances are shown by Pierre Goby, Hall-Edwards and others. These men have found it desirable in such work to use tubes in which the vacuum was widely different from that employed in ordinary radiographic work. For instance, in referring to a splendid radiograph of tulip blossoms, Hall-Edwards (Archives of the Roentgen ray, June, 1914), who is using tubes of the ordinary type (in this case a "Muller" with a Bauer regulator) notes that "it is rather dangerous to use new tubes for this purpose (although the best results can undoubtedly be obtained by them), for the reason that it is very easy to pass the boundary line and get a vacuum so low that it cannot be raised without re-exhausting the tube." Such difficulties, though they have not prevented securing beautiful radiographs, have doubtless kept this method of internal and structural photography from advancing as rapidly as it might otherwise have done.

The Coolidge X-ray tube[1] has proved itself to be an

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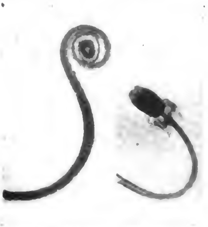
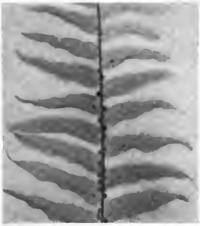
* Reproduced from the *General Electric Review*.

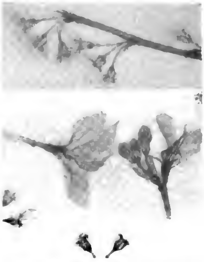
[1] See *Physical Review*, December, 1913, or *General Electric Review*, February, 1914.



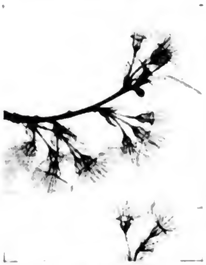
Fern bud and dandelion bud, illustrating wide latitude of type.



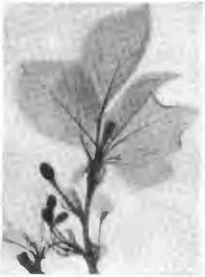
Fern leaf with colonies of bugs.



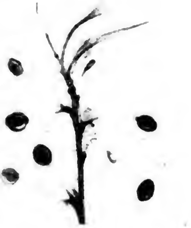
Cherry twigs, with young leaves, buds, and freshly opened flowers.



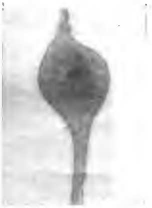
Cherry twigs with mature blossoms. Two blossoms have lost their petals.



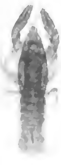
Cherry twig. The cherry is starting to form around the pit.



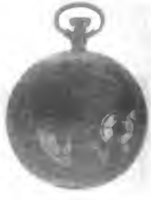
Cherry twig. The cherries here shown are about half developed.



Golden-rod gall. The worm inside is alive, and was not injured.



Crayfish. This subject differs from the tadpole, in that the bony structure is on the outside.



Ingersoll watch. Showing ease with which dense subjects can be examined.

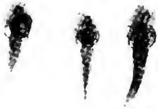
efficient tool in the hands of the medical profession, and it occurred to the writer that it would prove equally valuable to botanists and biologists in connection with the study of plant and animal life.

The main advantages in the use of the Coolidge tube are (1) the independence of the quantity and the penetrating ability of the rays produced, (2) the ease and rapidity with which the quantity and penetration of the rays may be regulated, and (3) the fact that when the tube is once adjusted to the requirements of the operator it needs no further attention. To bring the tube to any desired adjustment, the operator pulls a handle which regulates the current through the tube, thus determining definitely the quantity of X-rays produced. He then adjusts the voltage across the tube until the penetration is of the desired degree. These adjustments are rapid and require the minimum of technical skill.

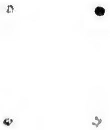
To illustrate this, the writer took a tube at random and took a number of radiographs of various botanical specimens. It was at once found that, when the proper penetration and exposure had been determined, the radiographs could be duplicated time after time with absolute precision. Then biological specimens were tried, and finally radiographs were taken of dense objects, such as fuse plugs and Ingersoll watches. As in the case of the botanical specimens, all of these radiographs could be accurately reproduced as often as desired.

The radiographs reproduced here were not chosen from the total number taken because of any novelty or excellence in the pictures themselves, but rather because they show what a wide range of work can be done with a single Coolidge tube, and because they suggest that the Coolidge tube is destined to become a precision instrument of value to the botanist, biologist and mineralogist as well as to the physicist and the physician.

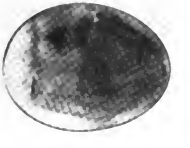
None of the pictures shown here have been retouched or altered in any way.



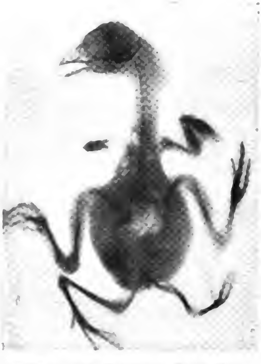
Tadpoles. Note growth of the intestines, and ossification of vertebrae.



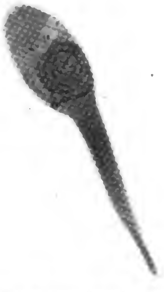
The substances most commonly used to imitate diamonds are fused oxide of aluminium, quartz, and lead glass. The figure shows a radiograph of these three as contrasted with a diamond of the same size. In the order of transparency to X-rays they are: diamond, fused oxide of aluminium, quartz, lead glass.



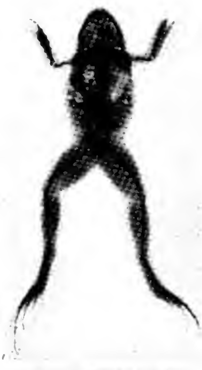
Egg, nearly hatched.



Four-legged chicken. Five hours old. Showing curious formation of the skeleton.



Tadpole. Magnified three and one half diameters. Note articles of food in the intestines.



A young frog. Ossification of the bones nearly complete.

Alcohol as a Motorcar Fuel

In some experiments recently made in England excellent results were obtained with alcohol as a fuel, the only change to the motor being an alteration of the carbureter jet. It is well known that many internal combustion motors designed for gasoline will run quite well when alcohol is used, but if the latter fuel was to be used exclusively, undoubtedly some increase in compression over that commonly used would be provided for, and the motor used in this test evidently had a fairly high compression.

The car was a 15/20 horse-power, with four 80 millimeter by 120 millimeter cylinders, and weighing 23¼ hundredweight approximately, the total running weight being 28¾ hundredweight approximately. The engine revolutions at 20 miles per hour were 903 per minute. The car was fitted with a Zenith carbureter, horizontal type, and beyond changing the jets between tests no other preparation for using the various fuels was made. The cubical contents of the compression space of a cylinder of the engine was 181.5 cubic centimeters, and the cubical contents of the volume swept by the piston was 603.18 cubic centimeters, giving a compression ratio of 4.3. The following fuels were used: Shell No. 2, benzol, commercial methylated spirit, containing the usual denaturants and 90 per cent of alcohol, and a mixture of equal parts of the two last fuels. All were purchased in the open market by the club. The trial was held upon Brooklands Track, and the weather was very hot. The following are the results of the tests:

Nominal speed, m.p.h.	Shell No. 2	Benzol.	Methylated spirit.	Equal parts methylated spirit and benzol
20	34 83 m.p.g.	40.39 m.p.g.	23 29 m.p.g.	32 41 m.p.g.
35	26 54 m.p.g.	31 25 m.p.g.	16 09 m.p.g.	23 34 m.p.g.
All out	42 28 m.p.h.	40 73 m.p.h.	40 84 m.p.h.	40 58 m.p.h.

The engine, on account of the hot weather, was always warm when started, and thus no difficulty was experienced in starting.

Commenting on these tests, the agents of the car used, remark: "The fact that the speed 'all out' on methylated spirits was comparable to the speeds obtained with other fuels seems to indicate that the use of denatured alcohol is merely a question of price, and that if this fuel were available in sufficiently large quantities at a sufficiently low price there are no serious obstacles in the way of its employment. We take it that these results may be of direct and immediate value as applied to the use of motor vehicles in many colonies and foreign countries. So far as Great Britain is concerned, the interest is in a sense academic, since the present price of methylated spirits is considerably higher than that of gasoline or benzol, largely owing to various restrictions in the manufacture and sale."

Heredity—I*

New Theories and Facts Relating to the History of Organic Beings

By Prof. William Bateson

Recognition of the significance of heredity is modern. The term itself in its scientific sense is no older than Herbert Spencer. Animals and plants are formed as pieces of living material split from the body of the parent organisms. Their powers and faculties are fixed in their physiological origin. They are the consequence of a genetic process, and yet it is only lately that this genetic process has become the subject of systematic research and experiment. The curiosity of naturalists has of course always been attracted to such problems; but that accurate knowlege of genetics is of paramount importance in any attempt to understand the nature of living things has only been realized quite lately, even by naturalists, and with casual exceptions the laity still know nothing of the matter. Historians debate the past of the human species, and statesmen order its present or profess to guide its future as if the animal man, the unit of their calculations, with his vast diversity of powers, were a homogenous material, which can be multiplied like shot.

The reason for this neglect lies in ignorance and misunderstanding of the nature of variation; for not until the fact of congenital diversity is grasped, with all that it imports, does knowledge of the system of hereditary transmission stand out as a primary necessity in the construction of any theory of evolution, or any scheme of human polity.

The first full perception of the significance of variation we owe to Darwin. The present generation of evolutionists realizes perhaps more fully than did the scientific world in the last century that the theory of evolution had occupied the thoughts of many and found acceptance with not a few before ever the "origin" appeared. We have come also to the conviction that the principle of natural selection cannot have been the chief factor in delimiting the species of animals and plants, such as we now with fuller knowledge see them actually to be. We are even more skeptical as to the validity of that appeal to changes in the conditions of life as direct causes of modification, upon which latterly at all events Darwin laid much emphasis. But that he was the first to provide a body of fact demonstrating the variability of living things, whatever be its causation, can never be questioned.

There are some older collections of evidence, chiefly the work of the French school, especially of Godron[1]—and I would mention also the almost forgotten essay of Wollaston[2]—these however are only fragments in comparison. Darwin regarded variability as a property inherent in living things, and eventually we must consider whether this conception is well founded; but postponing that inquiry for the present, we may declare that with him began a general recognition of variation as a phenomenon widely occurring in nature.

If a population consists of members which are not alike but differentiated, how will their characteristics be distributed among their offspring? This is the problem which the modern student of heredity sets out to investigate. Formerly it was hoped that by the simple inspection of embryological processes the modes of heredity might be ascertained, the actual mechanism by which the offspring is formed from the body of the parent. In that endeavor a noble pile of evidence has been accumulated. All that can be made visible by existing methods has been seen, but we come little if at all nearer to the central mystery. We see nothing that we can analyze further—nothing that can be translated into terms less inscrutable than the physiological events themselves. Not only does embryology give no direct aid, but the failure of cytology is, so far as I can judge, equally complete. The chromosomes of nearly related creatures may be utterly different both in number, size, and form. Only one piece of evidence encourages the old hope that a connection might be traceable between the visible characteristics of the body and those of the chromosomes. I refer of course to the accessory chromosome, which in many animals distinguishes the spermatozoon about to form a female in fertilization. Even it however cannot be claimed as the cause of sexual differentiation, for it may be paired in forms closely allied to those in which it is unpaired or accessory. The distinction may be present or wanting, like any other secondary sexual character. Indeed, so long as no one can show consistent distinctions between the cytological characters of somatic tissues in the same individual we can scarcely expect to perceive such distinctions between the chromosomes of the various types.

For these methods of attack we now substitute another, less ambitious, perhaps, because less comprehensive, but not less direct. If we cannot see how a fowl by its egg and its sperm gives rise to a chicken or how a sweet pea from its ovule and its pollen grain produces another sweet pea, we at least can watch the system by which the differences between the various kinds of fowls or between the various kinds of sweet peas are distributed among the offspring. By thus breaking the main problem up into its parts we give ourselves fresh chances. This analytical study we call mendelian because Mendel was the first to apply it. To be sure, he did not approach the problem by any such line of reasoning as I have sketched. His object was to determine the genetic definiteness of species; but though in his writings he makes no mention of inheritance it is clear that he had the extension in view. By cross-breeding he combined the characters of varieties in mongrel individuals and set himself to see how these characters would be distributed among the individuals of subsequent generations. Until he began this analysis nothing but the vaguest answers to such a question had been attempted. The existence of any orderly system of descent was never even suspected. In their manifold complexity human characteristics seemed to follow no obvious system, and the fact was taken as a fair sample of the working of heredity.

Misconception was especially brought in by describing descent in terms of "blood." The common speech uses expressions such as consanguinity, pure-blooded, half-blood, and the like, which call up a misleading picture to the mind. Blood is in some respects a fluid, and thus it is supposed that this fluid can be both quantitatively and qualitatively diluted with other bloods, just as treacle can be diluted with water. Blood in primitive physiology being the peculiar vehicle of life, at once its essence and its corporeal abode, these ideas of dilution and compounding of characters in the commingling of bloods inevitably suggest that the ingredients of the mixture once combined are inseparable, that they can be brought together in any relative amounts, and in short that in heredity we are concerned mainly with a quantitative problem. Truer notions of genetic physiology are given by the Hebrew expression "seed." If we speak of a man as "of the blood-royal" we think at once of plebeian dilution, and we wonder how much of the royal fluid is likely to be "in his veins"; but if we say he is "of the seed of Abraham" we feel something of the permanence and indestructibility of that germ which can be divided and scattered among all nations, but remains recognizable in type and characteristics after 4000 years.

I knew a breeder who had a chest containing bottles of colored liquids by which he used to illustrate the relationships of his dogs, pouring from one to another and titrating them quantitatively to illustrate their pedigrees. Galton was beset by the same kind of mistake when he promulgated his "Law of Ancestral Heredity." With modern research all this has been cleared away. The allotment of characteristics among offspring is not accomplished by the exudation of drops of a tincture representing the sum of the characteristics of the parent organism, but by a process of *cell division*, in which numbers of these characters, or rather the elements upon which they depend, are sorted out among the resulting germ-cells in an orderly fashion. What these elements, or *factors* as we call them, are we do not know. That they are in some way directly transmitted by the material of the ovum and of the spermatozoon is obvious, but it seems to me unlikely that they are in any simple or literal sense material particles. I suspect rather that their properties depend on some phenomenon of arrangement. However that may be, analytical breeding proves that it is according to the distribution of these genetic factors, to use a non-committal term, that the characters of the offspring are decided. The first business of experimental genetics is to determine their number and interactions, and then to make an analysis of the various types of life.

Now the ordinary genealogical trees, such as those which the stud-books provide in the case of the domestic animals, or the Heralds' College provides in the case of man, tell nothing of all this. Such methods of depicting descent cannot even show the one thing they are devised to show—purity of "blood." For at last we know the physiological meaning of that expression. An organism is pure-bred when it has been formed by the union in fertilization of two germ-cells which are alike in the factors they bear; and since the factors for the several characteristics are independent of each other, this question of purity must be separately considered for each of them. A man, for example, may be pure-bred in respect of his musical ability and cross-bred in respect of the color of his eyes or the shape of his mouth. Though we know nothing of the essential nature of these factors, we know a good deal of their powers. They may confer height, color, shape, instincts, powers both of mind and body; indeed, so many of the attributes which animals and plants possess that we feel justified in the expectation that with continued analysis they will be proved to be responsible for most if not all of the differences by which the varying individuals of any species are distinguished from each other. I will not assert that the greater differences which characterize distinct species are due generally to such independent factors, but that is the conclusion to which the available evidence points. All this is now so well understood, and has been so often demonstrated and expounded, that details of evidence are now superfluous.

But for the benefit of those who are unfamiliar with such work let me briefly epitomize its main features and consequences. Since genetic factors are definite things, either present in or absent from any germ-cell, the individual may be either "pure-bred" for any particular factor, or its absence, if he is constituted by the union of two germ-cells both possessing or both destitute of that factor. If the individual is thus pure, all his germ-cells will in that respect be identical, for they are simply bits of the similar germ-cells which united in fertilization to produce the parent organism. We thus reach the essential principle, that an organism cannot pass on to offspring a factor which it did not itself receive in fertilization. Parents, therefore, which are both destitute of a given factor can only produce offspring equally destitute of it; and, on the contrary, parents both pure-bred for the presence of a factor produce offspring equally pure-bred for its presence. Whereas the germ-cells of the pure-bred are all alike, those of the cross-bred, which results from the union of dissimilar germ-cells, are mixed in character. Each positive factor segregates from its negative opposite, so that some germ-cells carry the factor and some do not. Once the factors have been identified by their effects, the average composition of the several kinds of families formed from the various matings can be predicted.

Only those who have themselves witnessed the fixed operations of these simple rules can feel their full significance. We come to look behind the simulacrum of the individual body and we endeavor to disintegrate its features into the genetic elements by whose union the body was formed. Set out in cold general phrases such discoveries may seem remote from ordinary life. Become familiar with them and you will find your outlook on the world has changed. Watch the effects of segregation among the living things with which you have to do—plants, fowls, dogs, horses, that mixed concourse of humanity we call the English race, your friends' children, your own children, yourself—and however firmly imagination be restrained to the bounds of the known and the proved, you will feel something of that range of insight into nature which mendelism has begun to give. The question is often asked whether there are not also in operation systems of descent quite other than those contemplated by the mendelian rules. I myself have expected such discoveries, but hitherto none have been plainly demonstrated. It is true we are often puzzled by the failure of a parental type to reappear in its completeness after a cross—the merino sheep or the fantail pigeon, for example. These exceptions may still be plausibly ascribed to the interference of a multitude of factors, a suggestion not easy to disprove; though it seems to me equally likely that segregation has been in reality imperfect. Of the descent of quantitative characters we still know practically nothing. These and hosts of difficult cases remain almost untouched. In particular the discovery of E. Baur, and the evidence of Winkler in regard to his "graft hybrids," both showing that the sub-epidermal layer of a plant—the layer from which the germ-cells are derived—may bear exclusively the characters of a part only of the soma, give hints of curious complications, and suggest that in plants at least the interrelations between soma and gamete may be far less simple than we have supposed. Nevertheless, speaking generally, we see nothing to indicate that qualitative characters descend, whether in plants or animals, according to systems which are incapable of factorial representation.

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* An address delivered at Melbourne and Sydney, Australia, before the British Association for the Advancement of Science.

[1] "De l'Espèce et des Races dans les Êtres Organisés," 1859.

[2] "On the Variation of Species," 1856.

The body of evidence accumulated by this method of analysis is now very large, and is still growing fast by the labors of many workers. Progress is also beginning along many novel and curious lines. The details are too technical for inclusion here. Suffice it to say that not only have we proof that segregation affects a vast range of characteristics, but in the course of our analysis, phenomena of most unexpected kinds have been encountered. Some of these things twenty years ago must have seemed inconceivable. For example, the two sets of sex organs, male and female of the same plant, may not be carrying the same characteristics; in some animals characteristics, quite independent of sex, may be distributed solely or predominantly to one sex; in certain species the male may be breeding true to its own type, while the female is permanently mongrel, throwing off eggs of a distinct variety in addition to those of its own type; characteristics, essentially independent, may be associated in special combinations which are largely retained in the next generation, so that among the grandchildren there is numerical preponderance of those combinations which existed in the grandparents—a discovery which introduces us to a new phenomenon of polarity in the organism.

We are accustomed to the fact that the fertilized egg has a polarity, a front and hind end for example; but we have now to recognize that it, or the primitive germinal cells formed from it, may have another polarity shown in the groupings of the parental elements. I am entirely sceptical as to the occurrence of segregation solely in the maturation of the germ-cells,[3] preferring at present to regard it as a special case of that patch-work condition we see in so many plants. These mosaics may break up, emitting bud-sports at various cell-divisions, and I suspect that the great regularity seen in the F_2 ratios of the cereals, for example, is a consequence of very late segregation, whereas the excessive irregularity found in other cases may be taken to indicate that segregation can happen at earlier stages of differentiation.

The paradoxical descent of color-blindness and other sex-limited conditions—formerly regarded as an inscrutable caprice of nature—has been represented with approximate correctness, and we already know something as to the way, or, perhaps, I should say ways, in which the determination of sex is accomplished in some of the forms of life—though, I hasten to add, we have no inkling as to any method by which that determination may be influenced or directed. It is obvious that such discoveries have bearings on most of the problems, whether theoretical or practical, in which animals and plants are concerned. Permanence or change of type, perfection of type, purity or mixture of race, "racial development," the succession of forms, from being vague phrases expressing matters of degree, are now seen to be capable of acquiring physiological meanings, already to some extent assigned with precision. For the naturalist—and it is to him that I am especially addressing myself to-day—these things are chiefly significant as relating to the history of organic beings—the Theory of Evolution, to use our modern name. They have, as I shall endeavor to show in my second address to be given in Sydney, an immediate reference to the conduct of human society.

I suppose that everyone is familiar in outline with the theory of the Origin of Species which Darwin promulgated. Through the last fifty years this theme of the natural selection of favored races has been developed and expounded in writings innumerable. Favored races certainly can replace others. The argument is sound, but we are doubtful of its value. For us, that debate stands adjourned. We go to Darwin for his incomparable collection of facts. We would fain emulate his scholarship, his width and his power of exposition, but to us he speaks no more with philosophical authority. We read his scheme of evolution as we would those of Lucretius or of Lamarck, delighting in their simplicity and their courage. The practical and experimental study of variation and heredity has not merely opened a new field; it has given a new point of view and new standards of criticism. Naturalists may still be found expounding teleological systems[4] which would have delighted Dr. Pangloss himself, but at the present time few are misled. The student of genetics knows that the time for the development of theory is not yet. He would rather stick to the seed-pan and the incubator.

In face of what we now know of the distribution of variability in nature the scope claimed for natural selection in determining the fixity of species must be greatly reduced. The doctrine of the survival of the fittest is undeniable so long as it is applied to the organism as a whole, but to attempt by this principle to find value in all definiteness of parts and functions, and in the name of science to see fitness everywhere, is mere eighteenth century optimism. Yet it was in application to the parts, to the details of specific difference, to the spots on the peacock's tail, to the coloring of an orchid flower, and hosts of such examples, that the potency of natural selection was urged with the strongest emphasis. Shorn of these pretensions the doctrine of the survival of favored races is a truism, helping scarcely at all to account for the diversity of species. Tolerance plays almost as considerable a part. By these admissions almost the last shred of that teleological fustian with which Victorian philosophy loved to clothe the theory of evolution is destroyed. Those who would proclaim that whatever is is right will be wise henceforth to base this faith frankly on the impregnable rock of superstition and to abstain from direct appeals to natural fact.

My predecessor said last year that in physics the age is one of rapid progress and profound scepticism. In at least as high a degree this is true of biology, and as a chief characteristic of modern evolutionary thought we must confess also to a deep but irksome humility in presence of great vital problems. Every theory of evolution must be such as to accord with the facts of physics and chemistry, a primary necessity to which our predecessors paid small heed. For them the unknown was a rich mine of possibilities on which they could freely draw. For us it is rather an impenetrable mountain out of which the truth can be chipped in rare and isolated fragments. Of the physics and chemistry of life we know next to nothing. Somehow the characters of living things are bound up in properties of colloids, and are largely determined by the chemical powers of enzymes, but the study of these classes of matter has only just begun. Living things are found by a simple experiment to have powers undreamt of, and who knows what may be behind?

Naturally we turn aside from generalities. It is no time to discuss the origin of the mollusca or of dicotyledons, while we are not even sure how it came to pass that *Primula obconica* has in twenty-five years produced its abundant new forms almost under our eyes. Knowledge of heredity has so reacted on our conceptions of variation that very competent men are even denying that variation in the old sense is a genuine occurrence at all. Variation is postulated as the basis of all evolutionary change. Do we then as a matter of fact find in the world about us variations occurring of such a kind as to warrant faith in a contemporary progressive evolution? Till lately most of us would have said "yes" without misgiving. We should have pointed, as Darwin did, to the immense range of diversity seen in many wild species, so commonly that the difficulty is to define the types themselves. Still more conclusive seemed the profusion of forms in the various domesticated animals and plants, most of them incapable of existing even for a generation in the wild state, and therefore fixed unquestionably by human selection. These, at least, for certain, are new forms, often distinct enough to pass the species, which have arisen by variation. But when analysis is applied to this mass of variation the matter wears a different aspect. Closely examined, what is the "variability" of wild species? What is the natural fact which is denoted by the statement that a given species exhibits much variation? Generally one of two things: either that the individuals collected in one locality differ among themselves; or perhaps more often that samples from separate localities differ from each other. As direct evidence of variation it is clearly to the first of these phenomena that we must have recourse—the heterogeneity of a population breeding together in one area. This heterogeneity may be in any degree, ranging from slight differences that systematists would disregard, to a complex variability such as we find in some moths, where there is an abundance of varieties so distinct that many would be classified as specific forms but for the fact that all are freely breeding together. Naturalists formerly supposed that any of these varieties might be bred from any of the others. Just as the reader of novels is prepared to find that any kind of parents might have any kind of children in the course of the story, so was the evolutionist ready to believe that any pair of moths might produce any of the varieties included in the species. Genetic analysis has disposed of all these mistakes. We have no longer the smallest doubt that in all these examples the varieties stand in a regular descending order, and that they are simply terms in a series of combinations of factors separately transmitted, of which each may be present or absent.

The appearance of contemporary variability proves to be an illusion. Variation from step to step in the series must occur either by the addition or by the loss of a factor. Now, of the origin of new forms *by loss* there seems to me to be fairly clear evidence, but of the *contemporary acquisition* of any new factor I see no satisfactory proof, though I admit there are rare examples which may be so interpreted. We are left with a picture of variation utterly different from that which we saw at first. Variation now stands out as a definite physiological event. We have done with the notion that Darwin came latterly to favor, that large differences can arise by accumulation of small differences. Such small differences are often mere ephemeral effects of conditions of life, and as such are not transmissible; but even small differences, when truly genetic, are factorial like the larger ones, and there is not the slightest reason for supposing that they are capable of summation. As to the origin or source of these positive separable factors, we are without any indication or surmise. By their effects we know them to be definite, as definite, say, as the organisms which produce diseases; but how they arise and how they come to take part in the composition of the living creature so that when present they are treated in cell-division as constituents of the germs, we cannot conjecture.

(To be continued.)

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[3] The fact that in certain plants the male and female organs respectively carry distinct factors may be quoted as almost decisively negativing the suggestion that segregation is confined to the reduction division.

[4] I take the following from the Abstract of a recent Croonian Lecture "On the Origin of Mammals," delivered to the Royal Society: "In Upper Triassic times the larger Cynodonts preyed upon the large Anomodont, *Kannemeyeria*, and carried on their existence so long as these Anomodonts survived, but died out with them about the end of the Trias or in Rhaetic times. The small Cynodonts, having neither small Anomodonts nor small Cotylosaurs to feed on, were forced to hunt the very active long-limbed Thecodonts. The greatly increased activity brought about that series of changes which formed the mammals—the flexible skin with hair, the four-chambered heart and warm blood, the loose jaw with teeth for mastication, an increased development of tactile sensation, and a great increase of cerebrum. Not improbably the attacks of the newly evolved Cynodont or mammalian type brought about a corresponding evolution in the Pseudosuchian Thecodonts which ultimately resulted in the formation of Dinosaurs and Birds." Broom, R., "Proc. Roy. Soc.," B., 87, p. 88.

Combined Effect of Electric and Magnetic Fields on Spectrum Lines

By J. Stark

The helium line λ4471.646 was found by Lohmann [Abstract No. 617 (1908)] to yield a normal Zeeman triplet in the transverse effect; but when subject to an electric field of from 20,000 to 30,000 volts/centimeters the line gives a quartet with two components oscillating parallel to the field and two perpendicular to it. Two cases of the transverse effect occur with superimposed electric and magnetic fields: (1) Electric and magnetic fields parallel to one another. The question then arises as to whether in this case the two electric components of the line oscillating perpendicular to the electric field are each separated into a doublet by the magnetic field, while the two components oscillating parallel to the electric field remain unaffected, or does another kind of electromagnetic separation take place. (2) Electric and magnetic fields perpendicular to one another. Do the two electric components oscillating parallel to the electric field each split up into a doublet under the action of the magnetic field, the two perpendicular components remaining unaffected, or does another type of separation occur here? Experiments are being undertaken with a view to elucidating these problems. It was found that by the admission of a certain amount of hydrogen to the helium in the discharge tube the light emission of the canal rays in the mixture is more intense than in pure He. A description is given, with diagrams, of the apparatus to be used for investigating the combined effect of the electric and magnetic fields. The results of the experiments will be published later.—*Deutschen Phys. Gesellschaft.*

Influence of Occluded Gases of the Selective Photoelectric Effect

By R. Pohl and P. Pringsheim

Potassium which had been boiled continuously for in one case 180 hours and in another 430 hours in an extremely good vacuum, whereby its yield of occluded hydrogen changed from 2 cubic centimeters to 4×10^{-4} cubic centimeters per hour per cubic centimeter of potassium, was found to give the same selective photoelectric effect to within the limits of experimental error as potassium not so treated. The presence of hydrogen in the metal does not therefore appear to be of prime importance. This result is in direct opposition to that obtained by Wiedemann and Hallwachs [see Abstract No. 722 (1914)], the cause of which the authors are unable to explain. A general discussion on the causes of the emission of electrons by short electromagnetic waves, by chemical action, and by heat and the possibility of connecting them is included.—*Deutsches Phys. Gesellschaft.*

Artificial Versus Natural Ice

Facts Showing that Wholesome Artificial Ice Can be Produced in Competition With the Natural Article

THAT artificial ice is not more generally produced, and used, is to be greatly regretted in view of the rapidly decreasing sources from which natural ice that is free from contamination can be obtained. Indeed, it would be difficult to find a stream or lake that is entirely free from suspicion.

From time immemorial it has been the custom of all people, both the savage and the supposedly civilized, to dispose of their refuse in the nearest stream or body of water on the principle "out of sight out of mind," and as this custom still prevails, with the rapidly increasing density of population, probably no body of water suitable for producing ice within a commercially practical distance of the regions where ice is required could be found that has not been subject to this primitive abuse of being converted into a sewer.

While natural ice, properly isolated, is entirely suitable for use in cold storage warehouses, and under similar conditions, there is no doubt but much that is now sold to the public is not fit for human consumption, and the time is not far off when official recognition of this fact will be made by the authorities charged with the supervision of pure foods.

A timely article on the production of artificial ice, and demonstrating that it can be produced and sold in competition with natural ice, by A. R. Smith of the engineering department of the General Electric Company, appears in the August issue of the *General Electric Review*, extracts from which are subjoined:

A luxury of to-day becomes a necessity of to-morrow, and conditions which we are content to endure at present are almost unbearable when one becomes accustomed to better conditions. These statements are pertinent to the users of natural ice. It is strange how critical is a community using artificial ice, but the fact is that artificial ice rejected by the customers in the South would be accepted as good quality ice by the patrons of the natural product. Now, why is it that there is so little competition between natural and artificial products in colder climates? Is it the general belief that artificial ice cannot be sold at the same price as natural ice; or, that there is no market for good ice at a slightly increased cost; or, that the initial investment for an ice plant is so great that capital cannot be readily obtained? The writer will attempt to dispel any such views by comparing the quality of ice and the cost of production.

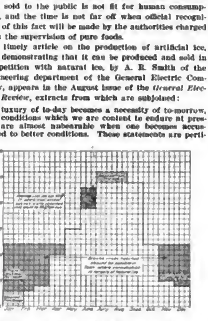


Fig. 1.—A representation of an average load curve for a 120-ton ice plant.

The fact that artificial ice is being marketed in the South at the same price and in some cases cheaper than natural ice is sold in the North, is very good evidence that competition is feasible in cold climates. As an example, an ice plant manufacturing ice at the rate of 20,000 tons per year and distributing to a trade within a radius of five miles, retails the ice at $8 per ton; whereas, in a Northern city of 100,000 inhabitants, a company harvesting approximately 30,000 tons per year and distributing within a radius of two miles, retails it at $12 per ton.

It is true that the ice season extends over a longer period in the South, but there is not so great a difference as one might imagine. It is also true that in the South the coal and ice business is frequently combined, and the same help and teams are used all the year round, which condition is not so applicable to Northern cities, where the majority of people purchase their winter coal supply in the summer. But the superiority of artificial ice should result in a market the entire year when sold in conjunction with natural ice. And, because of the reduced cost of manufacturing ice under high load factor conditions, it should be possible to make a better price to those who purchase ice at all seasons of the year.

Estimates are given in the *Review* which show that a plant of 120 tons daily capacity, or 23,340 tons a year, would cost approximately $92,000, on which the fixed charges would be 45½ cents per ton, while the cost of production would be 93½ cents, making a total of $1.39 per ton as against 29.8 cents for natural ice. These figures, however, do not cover the cost of distribution.

From the above it will be noted that if artificial ice is sold at $9 per ton and natural ice at $8 per ton, the excess cost of the former would be compensated for. Or, if both are sold at $8 per ton, the percentage of the selling price remaining to cover the cost of distribution and profits would be 82⅝ per cent, 84½ per cent, and 96 per cent, respectively. However, the cost of distributing artificial ice should be less than natural ice because the delivery men are not required to cleanse each cake.

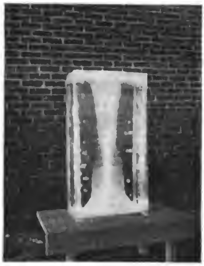


Fig. 3.—Illustration of a cake of artificial ice manufactured from distilled water.

Ice is frequently cut from lakes, ponds, and streams, the water of which would not be considered suitable for drinking purposes, filtered or unfiltered. This ice may be used in drinking water on the claim that the process of freezing purifies it. Acknowledging that this purification is true under certain conditions, because any visible impurities in artificial ice usually find their way to the core, the last part frozen, there are other considerations which would indicate that impurities can be entrapped. Ice is frequently permeated with particles of coke expelled from passing locomotives; impurities from the air are deposited on top of the ice by falling snow or rain and frozen fast to it; a fracture in the ice often causes the surface to be flooded, carrying with it stream sewage and other impurities, all of which may be entrapped by freezing.

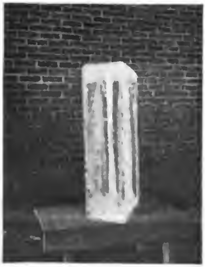


Fig. 4.—Another illustration of the cake of ice shown in Fig. 3. The central core which here appears to have considerable width would be only of line width in an edge-on view.

If it is conceded that natural ice should not be used as a direct cooling agent for drinks and edibles, then it loses one of its very important functions. However, it would be quite impractical to legislate against such use, and even difficult to evade the use of it personally when eating or drinking in public places.

Complaints on artificial ice are not unheard of, and they may be as follows: Salty ice, taste of ammonia, odor in core, presence of oil, presence of iron oxide.

In the can system, the cans are set in a brine, consisting usually of common salt water, but sometimes of a solution of calcium chloride. Should a leak develop and the water become salty, it will be detected by its flaky appearance immediately upon the removal of the cake from the can.

Ammonia contamination may occur in the double pipe pre-coolers, or the storage tank. But the former can be entirely dispensed with, with little effect on the cost, and the latter can be absolutely safeguarded by using continuous or welded expansion coils.

The odor in the core which may arise from the presence of oil is entirely eliminated when the water for making ice is obtained from the turbine condensers, as the steam never comes in contact with any lubricating oils. Odor arising from foul boilers is inexcusable if the boilers are properly cleaned and excessive use of boiler compounds avoided.

The presence of rust in the ice can be avoided by using galvanized or tinned piping and utensils for the distilled water, and exercising proper care to prevent oxidation when plant is not in operation, or by using brass piping.

Starting with the city drinking water or pure well water, it is first evaporated in the boilers, and then, after passing through the turbine, is condensed in a surface condenser. From the condenser it is pumped by means of a centrifugal pump to the reboilers, where it is thoroughly boiled to drive off the air and automatically skimmed of any floating material. Thence it passes through pipe coolers, where contamination from the cooling water can successfully ,be prevented, to charcoal filters and to the storage tank for filling the cans. In some cases it is again filtered through cheese cloth before entering the cans, but this operation should be unnecessary. The distilling process above mentioned destroys all bacterial life.

A quarter to one third of the natural product is what might be termed "snow ice." This contains usually most of the impurities and melts rapidly because of its spongy nature and consequently more surface exposed to the air. There is no difference in the lasting qualities of the crystal or clear ice, whether produced artificially or by nature.

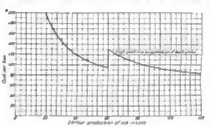


Fig. 2.—Curve showing the cost per ton of ice at different rates of production in a 120-ton plant.

A good quality of artificial ice contains no air except a slight trace forming the core, thus practically the entire weight represents crystal ice. In fact, cloudy artificial ice which may contain only a thin film of air lines just inside the surface and representing a much better grade than the natural product, would be rejected by the trade.

The actual weight of a cake of natural ice is a very uncertain quantity because of the irregular sizes and the loss due to melting in storage and during transportation. A 300-pound cake of artificial ice ought to weigh from 315 to 320 pounds to provide for shrinkage during delivery; and the weight is determined by setting of the automatic filler. The ice enters the handling room or storage room at approximately the freezing temperature, which should be about 14 deg. Fahr. Both these rooms are refrigerated to a temperature below 32 deg. Fahr. and there is no melting loss or necessity for packing with straw, sawdust, or the like. Really, the major portion of the ice is delivered to the wagons at a temperature somewhere between 14 and 30 deg. Fahr., depending on how long it stood in the handling room and how much heat was added to loosen it from the can. Therefore, a certain quantity of heat has to be absorbed by the ice before it reaches melting temperature, a distinct advantage over the natural ice which leaves the storage at just 32 deg. Fahr.

The reader should understand that there are many different and distinct systems of manufacturing ice from raw and distilled water and with and without compressors, and that the foregoing description applies to a comparatively commonplace can system.

New Divisions of the Inch

CERTAIN multiples or aliquot parts of an inch have been officially approved and verified by the Board of Trade, and will be recognized in England after November 1st. According to the schedule of the new denominations, the descriptive number of the equivalent of an inch is 15/0 B.G. (Birmingham gage). The new numbers proceed by units down to 1/0 B.G. (0.3964 inch), and then from 1 B.G. (0.3532 inch) to 52 B.G. (0.00095 inch).

Prof. William Bateson

President of British Association for the Advancement of Science.

Prof. William Bateson, F.R.S., the President-elect of the British Association, was born at Whitby, on August 8th, 1861, the son of the late Rev. W. H. Bateson, D.D., sometime Master of St. John's College, Cambridge. Educated in the first instance at Temple Grove School, he obtained a foundation scholarship at Rugby, afterward graduating at St. John's College, Cambridge. In 1885, Bateson was elected to a Fellowship of his College, and in 1887 became Balfour Student. The Royal Society conferred its Fellowship in 1894, and in 1904 he received the Darwin medal of that body for his researches on heredity and variation. Cambridge University elected him Professor of Biology in 1908, a post he held for a year, becoming then Director of the newly-founded John Innes Horticultural Institution at Merton Park, Surrey. In 1912, he was made Fullerian Professor of Physiology at the Royal Institution, a triennial appointment, shortly to be vacated.

Investigations in various departments of Zoology occupied the early part of Prof. Bateson's career, in particular, a research on the structure and development of Balanoglossus (the general name, it should be said, given to certain peculiar opaque worm-like animals which live an obscure life under stones, and burrow in sand, from between tide-marks down to the abyssal regions of the sea). The material was collected in America during visits to the Marine Laboratory of the Johns Hopkins University, Baltimore, and subsequently a series of papers on the research appeared in the *Quarterly Journal of Microscopical Science*. In 1886-87, he visited the Aral Sea, and the other salt, alkaline and bitter lakes in Western Central Asia, in order to study the fauna and any structural variations correlated with the existing life conditions.

Recognizing that variation was the bedrock upon which the theory of evolution rested, Prof. Bateson devoted himself to its study, and in 1894 published his "Materials for the Study of Variation." When, in 1900, biologists came to appreciate the researches of Gregor Johann Mendel, of Brünn (published as far back as 1865, but long overlooked) on the workings of heredity, as exemplified by experiments on the sowings of varieties of edible peas, Prof. Bateson took up the subject with enthusiasm, and soon announced that "with the re-discovery and confirmation of the principle which will henceforth be known as 'Mendel's Law,' the study of heredity and the cognate problems of evolution must enter on a new phase." In 1902 there appeared his "Mendel's Principles of Heredity."

Prof. William Bateson

The conclusions of Mendel's experiments have been admirably summarized by the Rev. W. Wilks, the distinguished horticulturist, he who gave us the famous Shirley poppy. If you cross pure yellow and pure green peas either way—it matters not which is seed-bearer and which pollen-bearer—you will get all yellow seeds. If you sow these hybrid seeds, each will, if it germinates, produce a plant which will bear, say, forty seeds, thirty of which will on the average be yellow, and ten green. The green, if sown and sown and sown for countless generations, will always bear green seeds, true to the original green parents (barring the always possible intervention of insects). Not so the thirty yellow. These when sown will on the average produce ten plants bearing all pure yellow seeds, which will be constant and true to the original yellow parent for countless generations. The remaining twenty plants will be impure yellows, each plant producing on the average one quarter of their seeds pure yellow, one quarter pure green, and one half impure yellow, which last will repeat the process and proportion practically for ever.

This law of inheritance, or ratio of results, forms the basis of that extension and application to general problems of heredity and variation, now so actively pursued by Prof. Bateson and his co-workers, among whom may be mentioned, Miss E. R. Saunders, Mr. R. C. Punnett, Miss Durham, Mr. L. Doncaster, and Mr. R. H. Biffen.

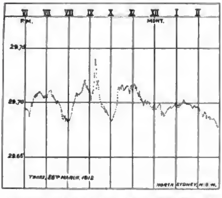
Prof. Bateson was Silliman Lecturer, Yale University, in 1907, when he discoursed on the bearing of Mendelian methods of analysis upon some of the wider problems of biology. These lectures were recently published in book form under the title, "Problems of Genetics."

Thread-Recording Micro-Barometer

The instrument from which the tracings here reproduced were obtained is a comparatively new type of recording apparatus in which friction is almost completely eliminated. The recording arm, or boom, of the aneroid is left free and unloaded by a pen; this means that the instrument can be made very sensitive, and is able to respond to the most minute variations of atmospheric pressure.

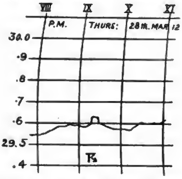
The principle made use of is that known as that of the "thread recorder"—a method of obtaining records from any delicate indicator—and originally applied to a ship's course recorder, or recording compass, by the inventor in 1902-1903. It consists essentially of an endless thread stretched on pulleys across and above the surface of the diagram, and kept continuously reinked in its passage over an inking roller. A slow motion is given to this thread by the driving clock. The end of the indicating arm is flattened so as to present its edge to the thread above which it swings. At intervals of one minute, or more frequently if required, this arm is pressed by a lever bar against the thread, forcing it down on the diagram, and thus making a dot. The individual minute dots can be seen in places where the increase or decrease of pressure has been rapid.

The photo reproduced herewith shows an instrument of this kind with paper 15 inches wide, and sufficient on one roll to last six months at the normal speed of one inch per hour. The record is automatically rewound on a second spool, from which it can be removed at any time.



Tracing from record given by a new form of micro-barometer during the passage of the thunderstorm and electrical disturbance of March 28th, 1912.

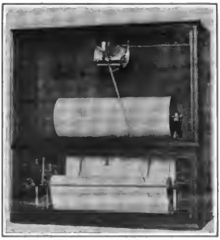
Showing the rapid fluctuations in atmospheric pressure usually associated with the presence of such disturbances. Magnification, 25 times; 2½ inches on diagram equals one tenth of an inch of mercury barometer.



Reproduction of a tracing (actual size) from one of the barographs of the Weather Bureau, Sydney Observatory, about three quarters of a mile distant from where the micro-barograph was situated.

The line drawing shows another design in which the record is visible for twenty-four hours after marking, and is rewound on a large diameter drum fixed outside the case for easier access.

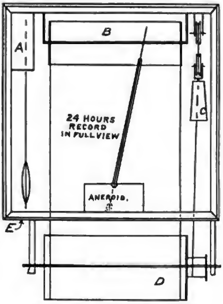
Unlike other micro-barographs which act on the "leaking off" principle, the diagrams of this instrument show the variations of atmospheric pressure in their relatively true value and correct sequence; while the time divisions are represented by straight lines.



Thread-recording micro-barometer supplied to the Weather Bureau, Melbourne.

In the latest design the driving clock is electric; the instrument is thus perfectly automatic, and may be left unattended for months at a time. The thread does not require attention more than two or three times a year.

Safety During Thunder Storms.—It would seem that the popular theory that a motorcar is one of the safest places during a severe thunder storm is also a popular fallacy. The idea that the rubber tires will act as an effectual bar to the passage of the electrical discharge may be exploded by anyone with the intrepidity to stand beside a car and place one finger upon the top of a spark plug with the motor running. The high tension current readily finds a path to the ground regardless of the tires. Why should not a bolt of lightning find a similar path?



Improved form of "thread-recording" micro-barometer.

A, Electric clock and pendulum; *B*, roll of paper 15 inches wide, six months' supply at 1 inch per hour; *C*, weight actuating rewinding drum, giving uniform pull on paper—one wind per month; *D*, rewinding drum, 8 inches diameter, fixed outside case; *E*, case, 2 feet 2 inches square, by 8 inches deep.

Liquid Crystals and Biology[*]

Discovery of New Properties of Matter Assist the Study of the Secret of Life

By Prof. O. Lehmann

The matter forming the physical basis of living organisms is usually regarded as a colloid substance, a mixture of extremely finely divided solid matter with a liquid of jelly-like consistency, or an emulsion of two liquids. Since such a mixture has no orderly structure, it is difficult to comprehend how the manifold, often very regular forms shown by organisms have come into existence and restore themselves after injury. Likewise the dynamic effects shown by organisms, as for instance the movement of an amœba in a definite direction, are not easily reconciled with the colloid nature of living matter. If, say, as a result of stimulation, the mass were to possess anisotropic structure, if only locally and temporarily, then the streaming of protoplasm would be far more comprehensible from a physical standpoint.

The chief objection to such an assumption is the presupposition that anisotropic structure can belong only to brittle solid bodies—the crystals, and that plastic and fluid crystals are an impossibility. Of course this follows from the old, almost axiomatic "theory of identity," according to which for example, ice water and steam have identical molecules, these molecules being arranged in different aggregates, as is supposed to be the case with the polymorphous modifications of sulphur. According to this old form of presenting the case the molecules of a molten mass are freely movable among themselves since cohesion and molecular directive force are supposed to be entirely overcome by the violent thermic motion of the molten state. At the instant of solidification all this is reversed and the molecules are supposed to "snap," as it were, into orderly arrangement, into so fixed a relationship that the thermic motion is entirely overcome, and all plasticity lost.

Since certain crystalline substances, especially metals, appear to be plastic as well as amorphous, the physicist labored under the necessity of explaining this phenomenon by assuming a shattering and then a re-welding of the fragments, the latter taking place by parallel shifting (translation).

Fluidity of a crystal, due to disturbance of its molecular arrangement, seemed inconceivable, since only two stable molecular arrangements were held to be possible, the absolute irregularity of the molten state and the perfectly regular disposition of the molecules in crystals.

Now, according to my results, between these two extremes of perfectly regular and entirely irregular molecular arrangement, a great number of intermediate forms are possible, the equilibrium between molecular forces and thermic motion is a stable equilibrium, changing with the temperature, and the apparent "snapping of the molecules" into order is merely an erroneous supposition, since in reality it is a sudden alteration in the molecules themselves which occurs, and which naturally occasions sharp transformations in the molecular forces. Furthermore, I found that through such molecular changes through the action of molecular directive force, mechanical work may be obtained, and that, too, directly from chemical energy, as in the case of work done by organisms.

My work began with the study of ammonium nitrate, and my object was, from the start, the observation of the life processes in organisms, the reasons for the forms they assume, and their power to do work, and comparison of these phenomena with those seen in non-living matter.

I found that the modification which appears with solidification of the molten mass at 161 degrees consists of very soft regular crystals, which again on cooling to 125.6 degrees first really crystallize in a tetragonal modification exactly as if they were liquid crystals. This again solidifies to a still stiffer monoclinic form at 82.8 degrees, which in turn at 32.1 degrees assumes a rhombic form, while at −16 degrees a tetragonal modification appears. On reheating, the substance "melts" into the ever softer modifications at the same temperatures. Here again the transformation cannot consist in the accepted "snapping" of the unchanged molecules into new arrangements, since in that case the observed identity of temperatures for the backward and forward change would be an impossibility, but the limiting temperatures to which the mass could be cooled or heated without snapping from one molecular arrangement into another would vary the more the greater the degree of firmness of the transformation. The identity of the ordinary points of melting and solidification had already been seen to contradict the "snap-theory" as does still more the existence of these transformation temperatures.

Moreover the significant alteration in characteristics, coincident with polymorphous transformations cannot be explained by this theory. I found that the long needles of the monoclinic form of ammonium nitrate could be bent into rings without injury to their transparency, and that they showed not the least variation in solubility at different points, although their molecular arrangement must have suffered much more static change than in any "shattering" process, of which there was not a trace. Also in polymorphous modifications no change in solubility could occur without a change in the molecules themselves as well as in their arrangement.

I was able to establish the possibility of disturbing the molecular arrangement by the admixture of foreign substances; naturally this had been excluded from the realm of possibility, the coloring of minerals and the artificial coloring of salts (Sénarmont) being regarded as a locking up of particles of coloring matter in so far as their molecules could not be considered so far similar physically and chemically (isomorphic) that they could replace those of the substance colored without destruction of the molecular arrangement.

Now isomorphic enmeshment (investiture) occasioned, according to my results, twisting and warping, which produced spherical crystals with a whole series of transitional forms between these and the normal crystals. These spherical forms are definitely recognizable as crystals, although the molecular order has been disturbed in the highest degree.

Of course, according to the old theory of crystallization, the formation of a liquid crystal is impossible, a crystal constantly altering and restoring its molecular order. The snapping into being is thought of as an irreversible process, which assumes the presence of a "limit of elasticity" (the internal friction of rest). Fluids are by definition bodies without a limit of elasticity, hence the absurdity of the whole idea. After I had recognized the accepted theory as false, it then became possible for me to entertain the idea of liquid crystals. The study of silver nitrate gave me the direct inspiration. At first I thought the modification appearing above 146 degrees amorphous and viscous, finding later that it was made up of regular crystals. Were these crystals then viscous? The decision could rest only on a determination of the limit of elasticity, which is the characteristic of the solid state, and for practical reasons this determination could not be carried out.

While I was considering these questions, F. Reinitzer sent me for examination a preparation of cholesteryl-benzoate, of which he wished to determine the molecular weight, which, however, when molten, was an opaque mass, the nature of which he could not clearly make out. He thought the opacity, which occurred on cooling, was due to the separation of solid crystals out of an isotropic molten mass, and that on raising the temperature oily streaks should appear in the molten mass of a modification more easily melted. Since for me the characteristic of a crystal was its ability to grow in polyhedric form, and since I could not find these shapes, I was at first at a loss; only after tedious study did I discover that the (apparently, not really) isotropic fluid containing the oily streaks is different from the isotropic molten mass, and has the same solubility as the oily streaks and crystals; also that it arises from these without change of temperature; therefore, I conjectured that we might here be dealing with liquid crystals, more fluid than those of silver iodide. Phenomena which I observed in a preparation sent me by L. Gattermann, also turbid when molten, strengthened my supposition of the existence of liquid crystals, but proof was lacking since I could not find the polyhedric form, the characteristic of crystals.

Real proof I obtained first with the hydrate of ammonium oleate, the myelin forms of which had already aroused my interest. Although these are typical liquid crystals, I did not immediately recognize them as such; first, because I did not find the distinguishing mark of polyhedric form, and second because they were regarded as tubular sacks of precipitation membrane (G. Quincke and others). So matters stood when the turbid iridescent molten cholesteryl-benzoate came up for study. Reinitzer's assumption that it was a jelly or an emulsion seemed probable, and there was nothing to be seen of fluid crystals, so naturally my conjecture aroused strong opposition, especially since the appearances were identical with those of the jelly-like myelin forms of ammonium oleate. I took up again the study of ammonium oleate, and with this obtained the irrefutable proof of the existence of liquid crystals. I saw crystals which have the peculiarity when agitated of flowing together like two drops of liquid, and in such a way that the normal order of equilibrium of the molecules and the normal form are again restored, as shown by optical and mechanical relations. This phenomenon I called "spontaneous homoiotropy." It was something entirely new.

In the case of these crystals there can have been no "snapping" into fixed molecular order, and there can be no state of stress as when elastic or plastic solid crystals are bent. Their molecules behave rather like free-moving astatic magnetic systems in constant motion, yet in stable equilibrium in their orientation. Every twist out of the natural position of equilibrium vanishes instantly as a result of molecular directive energy, since continuous elastic tension cannot exist. The limit of elasticity must then be zero. The crystals not only can but must be described as liquid. Lecithin has been found to occur in liquid crystalline form, and we may find the same true of cholinoleate and protagon.

Protagon, lecithin, cholesterin-ester, and oleate are found in brain, nerves, etc., and are extremely important to all vital processes.

Probably these are not the only liquid crystalline substances contained in living matter, since their recognition as such came about through their double refraction, which may be so slight, in case it exists at all, as to be entirely unobservable in microscopic layers. Hence it cannot be decided microscopically whether a liquid seen only in layers of microscopic thickness is amorphous or crystalline. Even in case of the above-named substances this occasionally proves true in so far as their double refraction can be altered by a loose combination with other matter (especially water) as is true of solid crystals. For example, if water be gradually added to a solution of ammonium oleate hydrate then instead of the small slender pointed crystals, more and more rounded ones appear; plainly there is formed a combination richer in water, which enmeshes itself regularly oriented in the liquid crystals of the form poorer in water.

If normal liquid crystals of ammonium oleate hydrate are brought into contact with water (better spirits of ammonia) myelin forms appear, which are nothing less than mixed crystals of this sort, especially rich in water, and in which the optical axis stands everywhere radial to the cylindrical axis. The double refraction diminishes as the amount of contained water increases. Phrenosin or protagon swell like starch grains when warmed in water, giving rise to myelin forms in which double refraction disappears entirely, although the mechanical properties which distinguish them from amorphous or colloid matter remain unchanged, i. e., the ability to form themselves (and that without growing, like solid crystals) merely through the establishment of their internal molecular equilibrium, while maintaining their normal structure or producing mechanical work.

In all these points there are striking analogies between the behavior of these liquid crystals and the characteristics of living matter, so that the designation, "apparently living crystals" might in many cases be entirely justifiable. Among colloid substances no such analogies exist.

I cannot go into details here, but must emphasize the fact that the formation of tubular and cell-like hollow myelin forms is an entirely different matter from the formation of "artificial cells" out of colloid matter. The latter grow as a result of osmotic pressure and are closed precipitation membranes. If they are opened at any point, then of course the higher pressure within vanishes, and growth is no longer possible.

In myelin forms, on the contrary, growth is not disturbed in this way; here the pressure is less within and the low pressure enables them to suck in foreign substances like a cupping glass. This is the direct cause of their growth and peculiar structure, which exactly corresponds with the structure taken on by a liquid crystalline mass when sucked up into a very fine capillary tube. If an isotropic substance is also drawn up, then this forms a long cylindrical bubble in the axis of the tube exactly as in the case of hollow myelin forms.

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[*] Translated for the Scientific American Supplement from the *Biochemische Zeitschrift*, Band 63, Heft 1.

The low pressure within is the result of the stretching of the outer layers due to swelling. The work thus produced corresponds to the energy lost in the swelling, the chemical energy. With absorption of water, swelling occurs also on the inner surface, so that such open hollow myelin forms occasionally do not remain cylindrical, but may become bell-shaped.

The swelling is not to be confused with diffusion. The liquid crystal is no porous mass into whose pores any liquid whatever may be absorbed; but the foreign material first forms a loose chemical combination with the outermost layer, at the boundary between this and the next layer dissociation occurs, and a part combines with the subjacent layer, and so on, penetration taking place not simply by diffusion, but by a chemical process; the source of energy is then largely chemical energy.

Not alone through swelling can manifestations of energy occur, but also through transformations, that is, alterations in the molecules, where, since the transformation is a chemical process, the source of the power to do work is again chemical. Such dynamic effects are very striking in the myelin forms of protagon, which on solidification suddenly shorten themselves by half without alteration of their optical orientation, and on being warmed, as suddenly reassume their former mass. Even more interesting is the phenomenon seen in the myelin forms of ammonium oleate, which, on being cooled below —4 degrees suddenly tries to expand, being transformed into a mass of cylindrical rods of identical optical orientation and striking against one another at all angles; and which on being warmed above —4 degrees as suddenly reassume the usual curved forms. Here we have to do not with real solidification, but with a transformation into a viscous liquid crystalline modification.

At bottom all these dynamic effects are expressions of molecular directive energy, the effects of revolving electrons.

Attention has been called to the fact that in liquid crystals piezo-electrical phenomena might appear, which might possibly be related to the electric currents set up in connection with muscle contractions and with the transmission of stimuli in nerves.

Nothing definite has yet been done in this field; the study of myelin forms being still in its infancy.

Protection Against Fire on Board Ship

It is a remarkable fact that, notwithstanding the great developments that have taken place in every detail in the design of merchant steamships, little or no progress has been made toward the effectual protection of the vessel against fire excepting, perhaps, in the direction of improvements in the pumps and in the distribution of pressure water from them. In the case of warships it has for some years been realized that one of the dangers to be met in naval engagements is fire, due to the action of the explosive contents of the shells which may penetrate into the interior of the ship; and progress has been made in the direction of insuring that the whole of the interior fittings shall be of a non-combustible material. It cannot be said that there has been great loss in decorative effect, although in this matter the warship is in an entirely different position from the modern liner. No attempt has been made, even in warships, to introduce furniture made of metal which will resist fire, the theory being that, before an engagement is entered upon, all wooden furniture, as well as all portable combustible material, etc., will be jettisoned.

In the merchant service there is not the same risk of fire as with warships in action, but statistics show that during the past eight or ten years there have been annual averages of over 300 outbreaks of fire on board ship, either in port or at sea, while the number of ships completely destroyed by fire averages over twenty per annum. This may not seem a large figure when one remembers that on the register of the United Kingdom alone there are nearly 21,000 ships, and that probably throughout the world there are 50,000 ships continuously in service. At the same time the possible loss of life, and the probable destruction of property consequent on fire, should encourage careful consideration of all possible methods, not only of preventing an outbreak, but of quickly and effectually arresting it in the initial stages. Undoubtedly in the case of passenger ships the publication of the fact that something had been done toward this end would have an effect on the bookings corresponding to that resulting from the evidence given of the possession of life-boats for all. In the new Hamburg-American liners "Imperator" and "Vaterland," Grinnell sprinklers have been introduced, and this fact alone justifies a consideration of the effectiveness of this method of combating fire on board a ship.

The extent to which such automatic sprinklers are used in mills, factories, warehouses, stores, halls, theaters, etc., and the disposition of fire insurance companies to grant rebate on the premiums of fire insurance policies when sprinklers are fitted, is evidence in favor of the efficiency of the same system on board ship. The conditions, particularly in the passenger quarters, are most favorable, because here the space is so minutely divided up by iron decks, transverse bulkheads, and even by cabin and alleyway walls, that the initial outbreak of a fire is confined within a limited area, and were automatic sprinklers immediately brought into action, the fire would the more likely be quenched. As to the freezing of the water in the pipes—an argument sometimes used against the system—the dry-pipe system has proved an effective preventive. In this system, so-called pressure tanks are provided, containing sufficient water for a primary supply, and this water is held in check by a specially designed differential valve, having water pressure on one side and air pressure on the other. When the rise in temperature, due to the starting of a fire, melts the solder of the sprinkler, the opening of the head liberates the air, reducing the pressure, and the valve is opened by the water-pressure above it exceeding the air-pressure under it. Thus the water flows freely through the pipes and out of the open heads. The inspection department of the Associated Factory Mutual Fire Insurance Companies of America, which has been responsible for the fitting of sprinklers to quite a number of American ships, including coasting, river and lake passenger-steamers, estimates that with any sprinkler system on board ship the heads would be spaced about 10 feet apart, each protecting 100 square feet, and that the cost of such an installation would average about 16 shillings per head, excluding the cost of the pumps. In land practice the cost is only about 12 shillings per head, but the ship installation would probably cost more.

The treatment of holds where cargo is carried involves a special application, particularly where the cargo is of a material with a tendency to spontaneous combustion. It would be difficult for sprinklers, and even for a hose, to subdue a fire of this nature, although it might postpone serious consequences sufficiently long to enable the ship to reach port. The authority already quoted has adopted a system of introducing carbon dioxide into warehouse compartments, which are analogous to ships' holds. The carbon dioxide is purchasable in a form liquefied under pressure and contained in drums. The liquid gas is passed through pipes and exudes through openings at the top of the warehouse or hold, its specific gravity causing it to sink, and thus to penetrate the interstices of the cargo during its descent; the result is that combustion is rendered impossible, and the fire is either held in check or completely extinguished, the gas ultimately being driven out or sucked out by fans. The difficulty is that the carbon dioxide, though not explosive or directly dangerous to life, tends toward asphyxiation. But a man can live for a limited time in an atmosphere containing 10 to 15 per cent of it, and it is computed that from 30 to 40 per cent is sufficient to extinguish a fire. It is not dangerous to merchandise, and the quantity required is about a 50 pound cylinder per 1,000 cubic feet of air. Sulphur dioxide has been used, but the authority quoted found it objectionable, as men could not live in an atmosphere containing any appreciable amount of the gas; moreover, it is injurious to certain kinds of merchandise.

In addition to this means of extinguishing an outbreak, consideration should be had, in merchant-ship practice, to the adoption to a larger extent of metal in preference to wood. It is true that so-called fire-resisting paints are largely used, but there is doubt of the efficacy of the great majority of such paints. In preference to wood a light steel might be used, especially if lined with non-combustible insulating material in order to secure a more equable temperature within the cabins in climates where extreme weather conditions prevail. In recent years there has been considerable development in the simulation of wood-carving and decorative effect generally in the production of metal furniture; but, even so, we are a long way from achieving the artistic effects which can be got from wood. In the modern liner, however, plaster-of-paris, and other such materials are being more and more relied upon for decorative purposes. Indeed, in some of the newer ships it is difficult to grasp the fact that one is not in a room on shore, because of the treatment of the ceiling and walls. If this plaster-of-paris work proves to be lasting, a way is opened up for the use of light-steel partition walls with insulating materials in preference, or in addition, to the plaster-of-paris.

The question is largely one of expense. The substitution of steel and plaster for wooden decks, cabins, etc., in medium and large passenger vessels would involve an increase in expenditure up to 10 per cent of the cost of the entire ship, excluding even the extra cost of steel furniture, if such were used. This is a serious addition to the price of a ship, and when to it there has to be added the cost of automatic sprinklers, it will be obvious that the shipowner will have to consider whether the advantage accruing from increase in favor with the public, and consequently more consistently full passenger lists, with the addition of a reduction of insurance rates, can compensate him for the expenditure. There can be no question that a ship so treated would be more immune from the risks of fire than an ordinary vessel depending only upon the fire-pumps; but the final answer is, we fear, one concerned with the relation of safety, and its influence on earning power, to the cost involved. The matter is one that will be decided finally by the public. If they make it clear that they are ready to pay for increased security, then it is certain to be attained, for manufacturers will vie with one another in discovering new materials, and in devising novel methods of treating old ones to render them durable and artistic. Shipowners have shown such readiness to add to the comfort and speed of their vessels that there is no doubt they will meet all demands that are commercially practicable.

Theory of Compressible Atoms*

By Theodore W. Richards

Speculation concerning the ultimate nature of matter goes far back into the early history of mankind. As soon as several of the ancient Greek philosophers perceived that some kind of atomic hypothesis was the simplest method of accounting for things, they attempted to imagine the nature of the ultimate particles. The apparent permanence of the Universe suggested that these particles could never become worn out, and hence the ancients naïvely conceived of them as being indefinitely hard. Newton inherited this idea, and spoke more than once of "hard massy particles." Not much over a hundred years ago Dalton brought forward convincing quantitative evidence in favor of the atomic theory, putting it thus upon a firm basis; and the theory was later adopted by physicists to explain the pressure of gases. Throughout these considerations the ancient notion of hard, incompressible, but perfectly resilient, atoms persisted—partly because this assumption served as a convenient basis for mathematical analysis.

According to the tenets generally held during the last fifty years, solids and liquids, as well as gases, are supposed to be constituted of small hard atoms (or complexes of hard atoms called molecules) with wide empty spaces between them—these atoms being supposed to be each for itself in violent irregular motion to and fro, due to heat. There is, however, nothing in this philosophy to distinguish solids and liquids from gases, although in reality they are very different indeed. Such a conception gives a very reasonable picture of the state of a gas, but does not explain the fixed bulk of liquids nor the rigidity and impermeability of solids. To overcome these difficulties it was necessary in discussing solids and liquids to add to the hard imaginary incompressible particle a magic "sphere of influence" surrounding it, which would prevent its touching other atoms; but how this "sphere of influence" was constituted no one was quite prepared to say.

About fourteen years ago in studying the behavior of gases, I came to the conclusion that even with this dilute form of matter, the imaginary particles (although here widely separated) were still surrounded by "spheres of influence," somewhat but not very much larger than those imagined to exist in liquids; and it seemed that since a "sphere of influence" appears always to accompany the atom, the little hard particle in the middle might have no real physical significance; this imaginary hard particle appeared to be a purely arbitrary assumption. The so-called "sphere of influence" in all its relations acts as if it were really the important thing to be considered. Hence the question was proposed: Why should we not call this sphere of influence the atom itself, since it always accompanies the atom, and why should we pretend to know anything about how the material is distributed within its limits? The gain in this point of view is twofold. In the first place it concentrates the interest and attention upon the entity which actually comes into consideration; on the other hand, it abolishes an arbitrary hypothesis.

If we consider the "sphere of influence" as being the practical boundary of the atom, we must call the atom compressible, for the "sphere of influence" is compressible; in other words, liquids and solids are actually compressed when pressure is applied to them. If the atom is compressible and elastic throughout its substance, we may imagine vibration within it; thus heat may be explained even in closely packed atoms of this kind.

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* Reproduced from *Engineering*.

* So many partial, or inaccurate, statements of Prof. Richards's revolutionizing theory have been printed of late, that the Editor of the *Graduates' Magazine* requested him to prepare the above article. Reproduced from the Harvard *Graduates' Magazine*.

One can easily see that the new hypothesis is suggestive. If the atoms are compressible and are packed closely together in solids and liquids, may we not trace, through the alteration in bulk of substances during chemical change, the action of the chemical and cohesive affinities which hold the atoms together? May we not with the help of this study interpret anew the mysterious symmetry of crystals? May we not correlate numerous properties in relation to one another and by means of the fundamental conception show the mutual dependence of all the properties of matter?

Perhaps the best method of indicating how such an idea can be of service is to enumerate the investigations which this particular hypothesis has already called into being, and the results to which they have led.

In the first place the hypothesis stimulated the study of the densities of solids and liquids, and thus led to the securing of decidedly convincing evidence that chemical affinity really exerts pressure in its action. This conclusion is based on the fact that the action of powerful affinity was found to be coincident with increase in density, other things being equal. Intimations of this effect are to be found in a note of Humphry Davy's, and in some later writings; but nobody had before taken account of its relation to the compressibility of the substances concerned.

A similar relationship was shown to hold in lesser degree with regard to the cohesion which holds together molecules of the same kind. Hence it appeared that non-volatile substances (which are firmly held together by cohesion) would be expected, other things being equal, to have great density, and great surface tension. Moreover, such substances (because already much compressed by great cohesion) should possess only slight compressibility. These conclusions likewise were verified by the study of fact.

The theory, since it involved the study of compressibility, led to the devising of a new and convenient method for determining this somewhat elusive property. With the help of this method the compressibilities of thirty-five elements were determined in Boylston Hall—only one or two having been known before. It was found that in the case of the solid elements the compressibility shows periodic fluctuation as the atomic weight increases, and that in general, with elements as with compounds, the bulky volatile substances are the most easily compressible. This was new—neither the facts nor the explanation had been available before. The study of compressibility has since been taken up by Dr. Bridgman in the Jefferson Physical Laboratory, and he has made great progress in the study of the effect of high pressures.

Further, the theory suggested that if atoms are compressible, the uneven compression caused by differently applied chemical affinities might restrict the heat vibration supposed to exist within their elastic interiors. This restriction would lessen their heat-capacities (which are measured by the quantities of heat needed to cause a given change of temperature) and at the same time expel some heat vibration already present which could no longer be accommodated by the diminished heat capacity. Thus the theory predicted that when during a given reaction the heat capacities of the substances concerned were diminished one would expect also to find an output of heat during this reaction in excess of that corresponding to the chemical work. This common-sense explanation of the puzzle involved in the idea of "bound energy" immediately stimulated investigation of the changes of heat capacity of substances in relation to the corresponding changes in the heat evolved during chemical reaction, and also prompted the study of specific heats at very low temperatures. After the main relations had been qualitatively demonstrated at Harvard, the matter was taken up by Nernst in Berlin, and later by others; and the qualitative predictions of the theory have been abundantly verified, even if the mathematical addition of some more recent investigators have not always been as effective as might be wished. The amplified idea has been called the "Third Law of Thermodynamics," and although by no means thoroughly worked out, it gives promise of fundamental importance.

Another suggestive application of the theory concerns the idea of the "asymmetric" or unsymmetrical carbon atom proposed by van 't Hoff, which is the basis of so much of modern organic chemistry. The actually observed phenomena are exactly what one would expect if a compressible carbon atom were unequally compressed on four different sides by the four different affinities inherent in four other dissimilar atoms. This and other aspects of the theory were set forth in detail in the Faraday Lecture delivered in London two years ago.

The most recently published application of the hypothesis is its interpretation of *crystal form*. In a paper which has just appeared in the *Journal of the American Chemical Society*, various phenomena exhibited by crystals—such as their definite angles, the similarity of forms assumed by similar substances, and other details concerning their highly symmetrical shapes—are all accounted for according to the theory of compressible atoms in a fashion which seems (at least to the author) to be more satisfactory than any other thus far suggested.

Incidentally it may be noted that the theory is entirely consistent with the still more recent idea that the "atoms" themselves are composed of yet smaller corpuscles, although on the other hand I can see no reason why indivisible particles should not be compressible.

The applications of the theory to the interpretation of chemical phenomena and to the suggestion of new research are by no means exhausted. No significant objection to it has thus far been encountered; but even supposing that the idea should be supplanted in the future by something yet more satisfactory—and this is always a possibility in the progress of scientific thought—one would be inclined to say that the theory had already justified its existence. The saying of Scripture: "By their fruits ye shall know them," applies in full force to theories as well as to persons, and in the short span of its existence the theory has been fruitful. It has "acquired merit" in the only way open to any such hypothesis, namely, by stimulating new experimentation, and thus leading to the discovery of facts and laws previously unknown.

The Cinematograph in Research

In an extremely interesting lecture before the Fränkisch-Oberpfälzischer Section of the Verein deutscher Ingenieure (*Zeitschrift des Ver. deut. Ing.*, 1914, lviii, 268), Dr. Ing. Hans Goetz outlined the part cinematography had played in scientific and technical research, and suggested some of the things that may be expected of it in the future. After an introduction giving statistics, describing apparatus, and outlining the history of the invention, the lecturer takes up the position of moving picture photography among the means of reproducing phenomena to the senses. It differs from other means in that it correlates two of the basic quantities that physics deals with, time and extension in space.

The most obvious way in which the cinematograph may act as an aid to science is in recording rare phenomena, such as scenes in the life of seldom seen or difficultly accessible animals, unusual surgical operations, etc.—fields in which considerable success has been attained. Its usefulness only begins here, however. Just as the scale of objects may be varied when they are represented graphically, so the time scale of actions may be changed when they are represented by the cinematograph. By an increase in speed, Prof. Pfeffer of Leipzig has been able to reproduce in three minutes a 10-day period of growth of a horse-chestnut twig; pictures for this reproduction were taken at 5-minute intervals. A large field for the study of the growth of both plants and animals is thus opened up. Just as slow motions can be hastened so that it is possible to see the total effect in a truer perspective, so it is possible to retard and analyze quick movements, and the limits are only those of the speed with which the pictures can be taken. With the most refined mechanical devices it is not possible to take more than 250 pictures per second, but by illuminating the moving object with regularly succeeding electric sparks and photographing on a film moving continuously rather than intermittently, it was found possible to increase the number of exposures to 2,000 per second. Bull has studied the flight of insects in this manner.

From an engineering point of view the cinematograph has been most useful in studying projectiles and their effect on armor plate. Much higher frequencies had to be used than Bull obtained, and the apparatus employed differed from his in not using a mechanical interrupter; in series with the illuminating spark-gap was a large condenser, and in parallel with it a small one; the large condenser is charged by an induction machine, and when it is discharged the small condenser is alternately charged and discharged across the gap. The period of the alternations can be judged with fair accuracy by the tone. Since an explosion can take place in the five-thousandth part of a second, the speed of nine to fifty thousand exposures per second, obtained by this method, is sufficient to furnish interesting results. Since it is obviously impossible to have the camera near the object photographed, a special arrangement is used.

The cinematograph can also be used for making quantitative measurements of movements. The fall of a body has been studied by photographing on the same film the falling object and the hand of a chronograph, and in the same way the action of a steam hammer has been timed.

In these lines the cinematograph has just begun to be developed, and offers great possibilities in solving problems dealing with time and space in fields as wide apart as engineering and biology, and makes possible the study of motions so slow that it has hitherto been impossible to form conception of their whole meaning, or so fast that it has been almost impossible to form any conception of them at all.—*Journal of Industrial and Engineering Chemistry*.

Relative Bactericidal Power of Mercuric Salts

MERCURIC iodide is found to be far more active as a bactericide than mercuric chloride, mercuric cyanide, or mercuric benzoate. It is at least ten times more powerful than mercuric chloride, which is generally considered to be one of the most active of all antiseptics.—*Comptes rend.*

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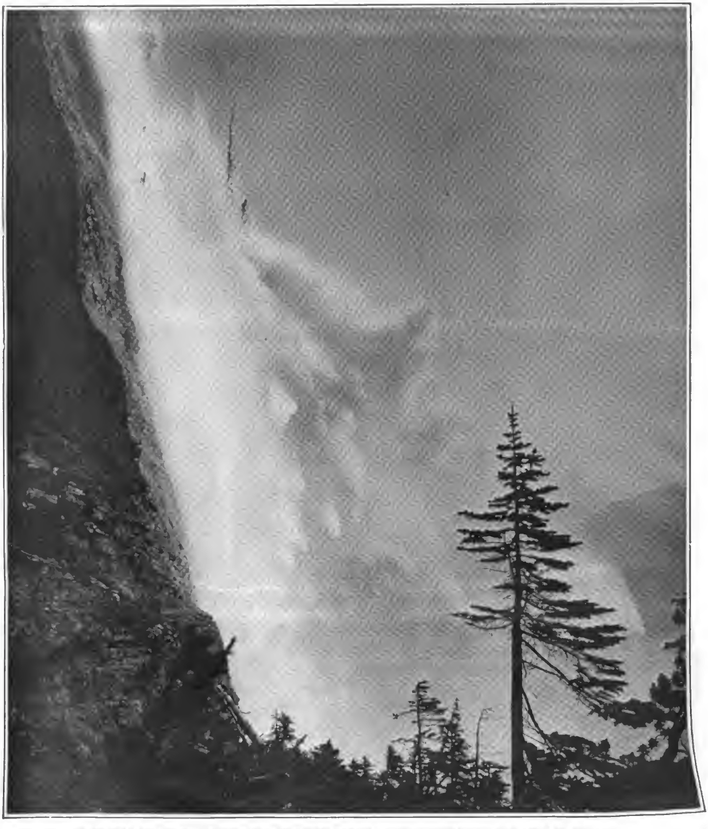

Emperor Falls, the outlet of Berg Lake to the Grand Fork River. Photo by Mr. R. C. W. Lett, Grand Trunk Pacific Railway.

THE PINNACLE OF THE CANADIAN ALPS.—[See page 183.]

Heredity—II[*]

New Theories and Facts Relating to the History of Organic Beings

By Prof. William Bateson

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2019, Page 171, September 12, 1914

IT was a commonplace of evolutionary theory that at least the domestic animals have been developed from a few wild types. Their origin was supposed to present no difficulty. The various races of fowl, for instance, all came from *Gallus bankiva*, the Indian jungle-fowl. So we are taught; but try to reconstruct the steps in their evolution and you realize your hopeless ignorance. To be sure there are breeds, such as black-red game and brown leghorns, which have the colors of the jungle-fowl, though they differ in shape and other respects. As we know so little as yet of the genetics of shape, let us assume that those transitions could be got over. Suppose, further, as is probable, that the absence of the maternal instinct in the leghorn is due to loss of one factor which the jungle-fowl possesses. So far we are on fairly safe ground. But how about white leghorns? Their origin may seem easy to imagine, since white varieties have often arisen in well-authenticated cases. But the white of white leghorns is not, as white in nature often is, due to the loss of the color elements, but to the action of something which inhibits their expression. Whence did that something come? The same question may be asked respecting the heavy breeds, such as Malays or Indian game. Each of these is a separate introduction from the East. To suppose that these, with their peculiar combs and close feathering, could have been developed from pre-existing European breeds is very difficult. On the other hand, there is no wild species now living any more like them. We may, of course, postulate that there was once such a species, now lost. That is quite conceivable, though the suggestion is purely speculative. I might thus go through the list of domesticated animals and plants of ancient origin and again and again we should be driven to this suggestion, that many of their distinctive characters must have been derived from some wild original now lost. Indeed, to this unsatisfying conclusion almost every careful writer on such subjects is now reduced. If we turn to modern evidence the case looks even worse. The new breeds of domestic animals made in recent times are the carefully selected products of recombination of pre-existing breeds. Most of the new varieties of cultivated plants are the outcome of deliberate crossing. There is generally no doubt in the matter. We have pretty full histories of these crosses in gladiolus, orchids, cineraria, begonia, calceolaria, pelargonium, etc. A very few certainly arise from a single origin. The sweet pea is the clearest case, and there are others which I should name with hesitation. The cyclamen is one of them, but we know that efforts to cross cyclamens were made early in the cultural history of the plant, and they may very well have been successful. Several plants for which single origins are alleged, such as the Chinese primrose, the dahlia, and tobacco, came to us in an already domesticated state, and their origins remain altogether mysterious. Formerly single origins were generally presumed, but at the present time numbers of the chief products of domestication, dogs, horses, cattle, sheep, poultry, wheat, oats, rice, plums, cherries, have in turn been accepted as "polyphyletic," or, in other words, derived from several distinct forms. The reason that has led to these judgments is that the distinctions between the chief varieties can be traced as far back as the evidence reaches, and that these distinctions are so great, so far transcending anything that we actually know variation capable of effecting, that it seems pleasanter to postpone the difficulty, relegating the critical differentiation to some misty antiquity into which we shall not be asked to penetrate. For it need scarcely be said that this is mere procrastination. If the origin of a form under domestication is hard to imagine, it becomes no easier to conceive of such enormous deviations from type coming to pass in the wild state. Examine any two thoroughly distinct species which meet each other in their distribution, as, for instance, *Lychnis diurna* and *vespertina* do. In areas of overlap are many intermediate forms. These used to be taken to be transitional steps, and the specific distinctness of *vespertina* and *diurna* was on that account questioned. Once it is known that these supposed intergrades are merely mongrels between the two species the transition from one to the other is practically beyond our powers of imagination to conceive. If both these can survive, why has their common parent perished? Why, when they cross, do they not reconstruct it instead of producing partially sterile hybrids? I take this example to show how entirely the facts were formerly misinterpreted.

When once the idea of a true-breeding—or, as we say, homozygous—type is grasped, the problem of variation becomes an insistent oppression. What can make such a type vary? We know, of course, one way by which novelty can be introduced—by crossing. Cross two well-marked varieties—for instance, of Chinese primula—each breeding true, and in the second generation by mere recombination of the various factors which the two parental types severally introduced, there will be a profusion of forms, utterly unlike each other, distinct also from the original parents. Many of these can be bred true, and if found wild would certainly be described as good species. Confronted by the difficulty I have put before you, and contemplating such amazing polymorphism in the second generation from a cross in *Antirrhinum*, Lotsy has lately with great courage suggested to us that all variation may be due to such crossing. I do not disguise my sympathy with this effort. After the blind complacency of conventional evolutionists it is refreshing to meet so frank an acknowledgment of the hardness of the problem. Lotsy's utterance will at least do something to expose the artificiality of systematic zoology and botany. Whatever might or might not be revealed by experimental breeding, it is certain that without such tests we are merely guessing when we profess to distinguish specific limits and to declare that this is a species and that a variety. The only definable unit in classification is the homozygous form which breeds true. When we presume to say that such and such differences are trivial and such others valid, we are commonly embarking on a course for which there is no physiological warrant. Who could have foreseen that the apple and the pear—so like each other that their botanical differences are evasive—could not be crossed together, though species of antirrhinum so totally unlike each other as *majus* and *molle* can be hybridized, as Baur has shown, without a sign of impaired fertility? Jordan was perfectly right. The true-breeding forms which he distinguished in such multitudes are real entities, though the great systematists, dispensing with such laborious analysis, have pooled them into arbitrary linnean species, for the convenience of collectors and for the simplification of catalogues. Such pragmatical considerations may mean much in the museum, but with them the student of the physiology of variation has nothing to do. These "little species," finely cut, true-breeding, and innumerable mongrels between them, are what he finds when he examines any so-called variable type. On analysis the semblance of variability disappears, and the illusion is shown to be due to segregation and recombination of series of factors on pre-determined lines. As soon as the "little species" are separated out they are found to be fixed. In face of such a result we may well ask with Lotsy, is there such a thing as spontaneous variation anywhere? His answer is that there is not.

Abandoning the attempt to show that positive factors can be added to the original stock, we have further to confess that we cannot often actually prove variation by loss of factor to be a real phenomenon. Lotsy doubts whether even this phenomenon occurs. The sole source of variation, in his view, is crossing. But here I think he is on unsafe ground. When a well-established variety like "Crimson King" primula, bred by Messrs. Sutton in thousands of individuals, gives off, as it did a few years since, a salmon-colored variety, "Coral King," we might claim this as a genuine example of variation by loss. The new variety is a simple recessive. It differs from "Crimson King" only in one respect, the loss of a single color-factor, and, of course, bred true from its origin. To account for the appearance of such a new form by any process of crossing is exceedingly difficult. From the nature of the case there can have been no cross since "Crimson King" was established, and hence the salmon must have been concealed as a recessive from the first origin of that variety, even when it was represented by very few individuals, probably only by a single one. Surely, if any of these had been heterozygous for salmon this recessive could hardly have failed to appear during the process of self-fertilization by which the stock would be multiplied, even though that selfing may not have been strictly carried out. Examples like this seem to me practically conclusive.[1] They can be challenged, but not, I think, successfully. Then again in regard to those variations in number and division of parts which we call meristic, the reference of these to original cross-breeding is surely barred by the circumstances in which they often occur. There remain also the rare examples mentioned already in which a single wild origin may with much confidence be assumed. In spite of repeated trials, no one has yet succeeded in crossing the sweet pea with any other leguminous species. We know that early in its cultivated history it produced at least two marked varieties which I can only conceive of as spontaneously arising, though, no doubt, the profusion of forms we now have was made by the crossing of those original varieties. I mention the sweet pea thus prominently for another reason, that it introduces us to another though subsidiary form of variation, which may be described as a *fractionation* of factors. Some of my mendelian colleagues have spoken of genetic factors as permanent and indestructible. Relative permanence in a sense they have, for they commonly come out unchanged after segregation. But I am satisfied that they may occasionally undergo a quantitative disintegration, with the consequence that varieties are produced intermediate between the integral varieties from which they were derived. These disintegrated conditions I have spoken of as subtraction—or reduction—stages. For example, the Picotee sweet pea, with its purple edges, can surely be nothing but a condition produced by the factor which ordinarily makes the fully purple flower, quantitatively diminished. The pied animal, such as the Dutch rabbit, must similarly be regarded as the result of partial defect of the chromogen from which the pigment is formed, or conceivably of the factor which effects its oxidation. On such lines I think we may with great confidence interpret all those intergrading forms which breed true and are not produced by factorial interference.

It is to be inferred that these fractional degradations are the consequence of irregularities in segregation. We constantly see irregularities in the ordinary meristic processes, and in the distribution of somatic differentiation. We are familiar with half segments, with imperfect twinning, with leaves partially petaloid, with petals partially sepaloid. All these are evidences of departures from the normal regularity in the rhythms of repetition, or in those waves of differentiation by which the qualities are sorted out among the parts of the body. Similarly, when in segregation the qualities are sorted out among the germ-cells in certain critical cell-divisions, we cannot expect these differentiating divisions to be exempt from the imperfections and irregularities which are found in all the grosser divisions that we can observe. If I am right, we shall find evidence of these irregularities in the association of unconformable numbers with the appearance of the novelties which I have called fractional. In passing let us note how the history of the sweet pea belies those ideas of a continuous evolution with which we had formerly to contend. The big varieties came first. The little ones have arisen later, as I suggest by fractionation. Presented with a collection of modern sweet peas how prettily would the devotees of continuity have arranged them in a graduated series, showing how every intergrade could be found, passing from the full color of the wild Sicilian species in one direction to white, in the other to the deep purple of "Black Prince," though happily we know these two to be among the earliest to have appeared.

Having in view these and other considerations which might be developed, I feel no reasonable doubt that though we may have to forgo a claim to variations by addition of factors, yet variation both by loss of factors and by fractionation of factors is a genuine phenomenon of contemporary nature. If then we have to dispense, as seems likely, with any addition from without we must begin seriously to consider whether the course of evolution can at all reasonably be represented as an unpacking of an original complex which contained within itself the whole range of diversity which living things present. I do not suggest that we should come to a judgment as to what is or is not probable in these respects. As I have said already, this is no time for devising theories of evolution, and I propound none. But as we have got to recognize that there has been an evolution, that somehow or other the forms of life have arisen from fewer forms, we may as well see whether we are limited to the old view that evolutionary progress is from the simple to the complex, and whether after all it is conceivable that the process was the other way about. When the facts of genetic discovery become familiarly known to biologists, and cease to be the preoccupation of a few, as they still are, many and long discussions must inevitably arise on the question, and I offer these remarks to prepare the ground. I ask you simply to open your minds to this possibility. It involves a certain effort. We have to reverse our habitual modes of thought. At first it may seem rank absurdity to suppose that the primordial form or forms of protoplasm could have contained complexity enough to produce the divers types of life. But is it easier to imagine that these powers could have been conveyed by extrinsic additions? Of what nature could these additions be? Additions of material cannot surely be in question. We are told that salts of iron in the soil may turn a pink hydrangea blue. The iron cannot be passed on to the next generation. How can the iron multiply itself? The power to assimilate the iron is all that can be transmitted. A disease-producing organism like the pebrine of silkworms can in a very few cases be passed on through the germ-cells. Such an organism can multiply and can produce its characteristic effects in the next generation. But it does not become part of the invaded host, and we cannot conceive it taking part in the geometrically ordered processes of segregation. These illustrations may seem too gross; but what refinement will meet the requirements of the problem, that the thing introduced must be, as the living organism itself is, capable of multiplication and of subordinating itself in a definite system of segregation? That which is conferred in variation must rather itself be a change, not of material, but of arrangement, or of motion. The invocation of additions extrinsic to the organism does not seriously help us to imagine how the power to change can be conferred, and if it proves that hope in that direction must be abandoned, I think we lose very little. By the re-arrangement of a very moderate number of things we soon reach a number of possibilities practically infinite.

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[*] An address delivered at Melbourne, Australia, by Prof. William Bateson, M.A., F.R.S., President, before the British Association for the Advancement of Science.

[1] The numerous and most interesting "mutations" recorded by Prof. T. H. Morgan and his colleagues in the fly, *Drosophila*, may also be cited as unexceptionable cases.

That primordial life may have been of small dimensions need not disturb us. Quantity is of no account in these considerations. Shakespeare once existed as a speck of protoplasm not so big as a small pin's head. To this nothing was added that would not equally well have served to build up a baboon or a rat. Let us consider how far we can get by the process of removal of what we call "epistatic" factors, in other words those that control, mask, or suppress underlying powers and faculties. I have spoken of the vast range of colors exhibited by modern sweet peas. There is no question that these have been derived from the one wild bi-color form by a process of successive removals. When the vast range of form, size, and flavor to be found among the cultivated apples is considered it seems difficult to suppose that all this variety is hidden in the wild crab apple. I cannot positively assert that this is so, but I think all familiar with mendelian analysis would agree with me that it is probable, and that the wild crab contains presumably inhibiting elements which the cultivated kinds have lost. The legend that the seedlings of cultivated apples become crabs is often repeated. After many inquiries among the raisers of apple seedlings I have never found an authentic case—once only even an alleged case, and this on inquiry proved to be unfounded. I have confidence that the artistic gifts of mankind will prove to be due not to something added to the make-up of an ordinary man, but to the absence of factors which in the normal person inhibit the development of these gifts. They are almost beyond doubt to be looked upon as *releases* of powers normally suppressed. The instrument is there, but it is "stopped down." The scents of flowers or fruits, the finely repeated divisions that give its quality to the wool of the merino, or in an analogous case the multiplicity of quills to the tail of the fantail pigeon, are in all probability other examples of such releases. You may ask what guides us in the discrimination of the positive factors and how we can satisfy ourselves that the appearance of a quality is due to loss. It must be conceded that in these determinations we have as yet recourse only to the effects of dominance. When the tall pea is crossed with the dwarf, since the offspring is tall we say that the tall parent passed a factor into the cross-bred which makes it tall. The pure tall parent had two doses of this factor; the dwarf had none; and since the cross-bred is tall we say that one dose of the dominant tallness is enough to give the full height. The reasoning seems unanswerable. But the commoner result of crossing is the production of a form intermediate between the two pure parental types. In such examples we see clearly enough that the full parental characteristics can only appear when they are homozygous—formed from similar germ-cells, and that one dose is insufficient to produce either effect fully. When this is so we can never be sure which side is positive and which negative. Since, then, when dominance is incomplete we find ourselves in this difficulty, we perceive that the amount of the effect is our only criterion in distinguishing the positive from the negative, and when we return even to the example of the tall and dwarf peas the matter is not so certain as it seemed. Prof. Cockerell lately found among thousands of yellow sunflowers one which was partly red. By breeding he raised from this a form wholly red. Evidently the yellow and the wholly red are the pure forms, and the partially red is the heterozygote. We may then say that the yellow is *YY* with two doses of a positive factor which inhibits the development of pigment; the red is *yy*, with no dose of the inhibitor; and the partially red are *Yy*, with only one dose of it. But we might be tempted to think the red was a positive characteristic, and invert the expressions, representing the red as *RR*, the partly red as *Rr*, and the yellow as *rr*. According as we adopt the one or the other system of expression we shall interpret the evolutionary change as one of loss or as one of addition. May we not interpret the other apparent new dominants in the same way? The white dominant in the fowl or in the Chinese primula can inhibit color. But may it not be that the original colored fowl or primula had two doses of a factor which inhibited this inhibitor? The pepper moth, *Amphidasys betularia*, produced in England about 1840 a black variety, then a novelty, now common in certain areas, which behaves as a full dominant. The pure blacks are no blacker than the cross-bred. Though at first sight it seems that the black *must* have been something added, we can without absurdity suggest that the normal is the term in which two doses of inhibitor are present, and that in the absence of one of them the black appears.

In spite of seeming perversity, therefore, we have to admit that there is no evolutionary change which in the present state of our knowledge we can positively declare to be not due to loss. When this has been conceded it is natural to ask whether the removal of inhibiting factors may not be invoked in alleviation of the necessity which has driven students of the domestic breeds to refer their diversities to multiple origins. Something, no doubt, is to be hoped for in that direction, but not until much better and more extensive knowledge of what variation by loss may effect in the living body can we have any real assurance that this difficulty has been obviated. We should be greatly helped by some indication as to whether the origin of life has been single or multiple. Modern opinion is, perhaps, inclining to the multiple theory, but we have no real evidence. Indeed, the problem still stands outside the range of scientific investigation, and when we hear the spontaneous formation of formaldehyde mentioned as a possible first step in the origin of life, we think of Harry Lauder in the character of a Glasgow schoolboy pulling out his treasures from his pocket—"That's a washer—for makkin' motor cars"!

As the evidence stands at present all that can be safely added in amplification of the evolutionary creed may be summed up in the statement that variation occurs as a definite event often producing a sensibly discontinuous result; that the succession of varieties comes to pass by the elevation and establishment of sporadic groups of individuals owing to their origin to such isolated events; and that the change which we see as a nascent variation is often, perhaps always, one of loss. Modern research lends not the smallest encouragement or sanction to the view that gradual evolution occurs by the transformation of masses of individuals, though that fancy has fixed itself on popular imagination. The isolated events to which variation is due are evidently changes in the germinal tissues, probably in the manner in which they divide. It is likely that the occurrence of these variations is wholly irregular, and as to their causation we are absolutely without surmise or even plausible speculation. Distinct types once arisen, no doubt a profusion of the forms called species have been derived from them by simple crossing and subsequent recombination. New species may be now in course of creation by this means, but the limits of the process are obviously narrow. On the other hand, we see no changes in progress around us in the contemporary world which we can imagine likely to culminate in the evolution of forms distinct in the larger sense. By intercrossing dogs, jackals, and wolves new forms of these types can be made, some of which may be species, but I see no reason to think that from such material a fox could be bred in indefinite time, or that dogs could be bred from foxes.

Whether science will hereafter discover that certain groups can by peculiarities in their genetic physiology be declared to have a prerogative quality justifying their recognition as species in the old sense, and that the differences of others are of such a subordinate degree that they may in contrast be termed varieties, further genetic research alone can show. I myself anticipate that such a discovery will be made, but I cannot defend the opinion with positive conviction.

Somewhat reluctantly, and rather from a sense of duty, I have devoted most of this address to the evolutionary aspects of genetic research. We cannot keep these things out of our heads, though sometimes we wish we could. The outcome, as you will have seen, is negative, destroying much that till lately passed for gospel. Destruction may be useful, but it is a low kind of work. We are just about where Boyle was in the seventeenth century. We can dispose of Alchemy, but we cannot make more than a quasi-chemistry. We are awaiting our Priestley and our Mendeléeff. In truth it is not these wider aspects of genetics that are at present our chief concern. They will come in their time. The great advances of science are made like those of evolution, not by imperceptible mass-improvement, but by the sporadic birth of penetrative genius. The journeymen follow after him, widening and clearing up, as we are doing along the track that Mendel found.

(*To be continued.*)

Ozone in the Upper Atmosphere

According to J. N. Pring, in the *Proceedings* of the Royal Society, ozone can be distinguished from nitrogen oxides in very dilute gas mixtures with the aid of an aqueous solution of potassium iodide, provided the temperature does not fall below the freezing point of the reagent — 240 deg. Cent. Hydrogen peroxide would give the same reaction as ozone, but can be distinguished from it by the titanium sulphate test. The action of ultra-violet light on air is studied in a bulb, immediately surrounding the quartz tube of the mercury lamp, so that the rays pass through the quartz walls directly into the air; the whole apparatus is immersed in water. The arc is started with the aid of an induction coil, after joining the lamp terminals to a source of current at 100 or 200 volts; the secondary of the coil is also connected with one of these terminals, and, further, with a wire wrapped round the annular jacket of the lamp; the coil is worked until a glow discharge, followed by the arc, is seen in the lamp. In this apparatus no nitrogen oxides nor hydrogen peroxides were produced; the ozone production decreased when the gas pressure was reduced, from 0.01 per cent at 760 millimeters to 0.0014 per cent at 30 millimeters. With the absorbing vessels of Hayhurst and the author, atmospheric measurements were conducted in the Alps at altitudes between 2,000 and 3,500 meters. Free balloon measurements were made from Manchester. In the Alps the mean quantity of ozone found in one volume of air was 2.5×10^{-6} at 2,100 meters, and 4.7×10^{-6} at 3,580 meters; the amount did not increase much at higher altitudes up to 20 kilometers; the ozone contents fluctuated; nitrogen oxide and hydrogen peroxide were not observed in the upper atmosphere. The amount of ozone stated sufficed, as laboratory experiments indicated, to impart a blue color to the gas; thus ozone would contribute to the blue color of the sky.

Production of High Vacua by Means of Finely Divided Copper

T. R. Merton says in the *Journal* of the Chemical Society: Finely divided copper which may be obtained by reducing a solution of a copper salt and is sold commercially as "precipitated copper," absorbs gases with great readiness, the vapor pressure of the gases thus absorbed being so small that under suitable conditions it may be used for the production of high vacua. A bulb containing a few grammes of the copper is sealed to the vessel to be exhausted, the vessel being then partially exhausted by means of an air pump and the copper heated to about 250 degrees. When the air pump is disconnected and the copper allowed to cool, the residual gases are rapidly absorbed. This absorption is not due to chemical combinations, since the gases are liberated when the copper is heated. The carbon bands disappear first, then nitrogen, and finally hydrogen, but helium does not appear to be absorbed appreciably. Diminution in the absorbing power of the copper follows (1) the use of an excessively high temperature, (2) repeated use, or (3) prolonged exposure to the mercury-vapor from a mercury lamp. Great care is necessary when the copper is being used for the first time, as the occluded gases may sometimes be evolved with such violence that the copper is blown through into the pump; consequently not more than one third of the bulb should be filled with copper, and a short length of the tube connecting the bulb and the pump should be tightly packed with glass wool.

A New Application of Roentgen Rays*

An Infallible Means for Identifying Oil Paintings

A Roentgen ray image, or radiograph, of an oil painting resembles a rough sketch, rather than a photograph of the picture. The relative brightness of the colors is altered, the outlines are often displaced, and ugly spots and bands mar the general effect. These changes require a few words of explanation.

In a radiograph of the human body, the differences of brightness that distinguish the heart from the lungs, bone from flesh, etc., are due to differences in density of the various tissues. In a radiograph of an oil painting similar effects are produced by differences in density of the pigments, and especially by the atomic weight of their principal or heaviest elements, the influence of which may even reverse the effect of greater or less dilution with oil.

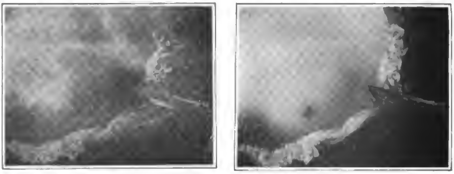
A scale of oil colors, arranged in accordance with their transparency to Roentgen rays, can be made by applying standard pigments to canvas in patches of equal thickness. When the direct, or negative, radiograph of a canvas thus painted is compared with its positive photograph, printed from a negative made by an orthochromatic process, a general resemblance is observed, but the gradation in tint, which has been made regular in the radiograph by the arrangement of the pigments, is strikingly irregular in the photograph. The comparison is made between the negative radiograph and the positive photograph because, in general, those pigments that are heaviest, or that contain elements of highest atomic weight, are lightest in color. In the negative radiograph that constitutes the Roentgen scale, light tints are produced by white, yellow, and red pigments (except the vegetable colors, Indian yellow and madder), medium tints by the greens and browns, and dark tints by all blues, blacks, and lakes.

It is evident, therefore, that juxtaposed pigments must reveal themselves, to some extent, in the radiograph of an oil painting. In the case of superposed pigments experiment confirms the theoretical conclusion that a design drawn in a heavy pigment will, in the radiograph, show through a superposed uniform layer of a less dense pigment, as bones show through flesh, while a design in pigment of low density will be almost completely masked by a superposed uniform coat of heavy pigment. The results are the same when the uniform layer underlies the design, for the tint of the radiograph is due to the summation of the opacities (to Roentgen rays) of all of the superposed layers.

In this summation, however, a heavy pigment outweighs even a medium pigment of thrice its thickness. Furthermore, dark colors are usually laid on thinly, while the heavy white and yellow pigments are applied very thickly, so that they are still more strongly contrasted in the radiograph.

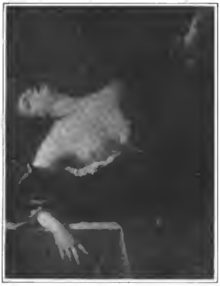
In short, an ordinary photograph reproduces only the surface of a painting, while a radiograph represents the projection of all of the superposed pigments, which produce effects in proportion to their densities. The grain of the canvas or wood shows likewise, but no appreciable effect is produced by a ground of paper or canvas, or by a coat of varnish.

Let us now consider the practical results that can be obtained from the examination of oil paintings with Roentgen rays. The first picture that I examined in this way was a "Lucretia," attributed to an Italian artist of the seventeenth century. I did not succeed in finding the signature I sought, but I made several interesting discoveries, which are illustrated in the accompanying photographs and radiographs. The flesh tones of the painting are very lifelike, especially in the neck, bosom, and shoulders. The figure reclines against a golden brown curtain, which contrasts but slightly with the chestnut hair, dark green bodice, and dark brown robe, while the steel dagger, with its gold-bronze hilt, stands out conspicuously from the yellowish-white frill of the opened chemise.


Radiograph. Photograph.

Bust of "Lucretia."

The radiograph shows an irregular light area in place of the dark bodice, the frill of the chemise appears torn and indistinct, and the blade of the dagger is lengthened.


"Lucretia," attributed to a seventeenth century Italian artist. (Photograph.)

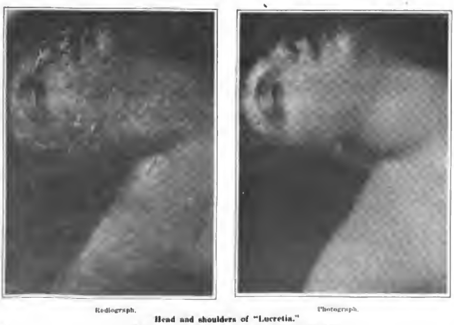
In the photograph this frill is sharply defined and clearly distinguished from the bodice, but in the radiograph it appears tattered and it overflows the bodice, the greater part of which, indeed, is replaced by a broad strip of nearly the hue of the frill. This leads me to suspect that the bodice was added as an afterthought, perhaps to diminish the area of white, and that the white chemise shows through it in the radiograph, for reasons already explained. The sharp white band below the dagger in the radiograph may indicate an alteration in the position of the weapon, the blade of which is a little longer than it is in the photograph.

The radiograph of the right hand shows a broad light band, which runs obliquely from the upper left corner to and beyond the table, and of which not a trace is discernible in the photograph or the painting. This may indicate a fold of the gown, subsequently altered, but it more probably represents the first rough sketch of the arm and hand. The narrow light band, parallel to the edge of the table, is faintly visible in the painting.

In the radiograph the third and little fingers are close together and a supernumerary finger appears between the index and middle fingers. From these and other differences I infer that the hand hung limp with the fingers nearly in contact in the first sketch, and that the fingers were afterward separated.

The most striking feature of these radiographs is their revelation of details of the first sketch, which have been altered in the finished picture. Thus we obtain an insight into the methods of an artist who has been dead for centuries. Information of a different sort is obtained by comparing the radiograph and the photograph of our Lucretia's head and shoulder. The picture was "restored" some twenty years ago, and the subsequent changes of tint of retouched parts of the face and shoulder are visible in the painting and, to some extent, in the photograph. The radiograph, however, clearly shows the flaking that led to the restoration. When the painting is examined by the transmitted light of a 32 candle-power metallic filament lamp, some of the flaked parts appear, less distinctly than in the radiograph, while others are quite invisible. Ordinary light reveals no trace of the long crack on the shoulder, which evidently was filled with a thick mass of pigment containing too little white lead to obliterate the crack, in the radiograph. The white spots above the ear probably indicate an excess of white lead used in retouching. At all events radiography appears to supply an excellent method of detecting alterations in oil paintings, although in some cases it leaves room for doubt whether the changes were made during the construction of the picture, or subsequently.

Although I could discover no signature on the Lucretia, probably because the picture was not signed, I found traces of a signature on another painting—


Radiograph. Photograph.

Head and shoulders of "Lucretia."

The radiograph shows flaked spots of picture before restoration.

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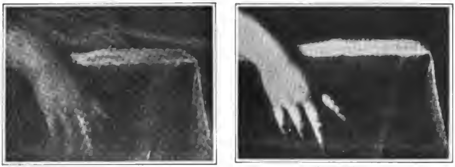
* Adapted from Dr. Alexander Faber's article in Umschau.

C. Sell's "Brigands"—where I was not looking for one, because the artist's name was written plainly, in small red letters, in the lower right-hand corner. (These letters are barely discernible in either the photograph or the radiograph, and are quite invisible in the reproductions here shown.)

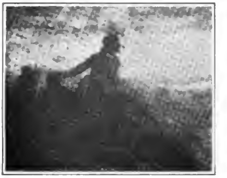
At the bottom of the radiograph, farther toward the left, I discovered traces of a much larger *C* and *S*, which did not appear in the photograph or the painting. Between these two letters were marks which I could not make out.

I infer that the artist first signed his picture with large initials, altered them a little, and then covered them with the greenish brown ground color, and wrote a smaller signature in the corner. This discovery shows the possibility of detecting by radiography a signature that has been painted over. The detection is easier in proportion to the density of the pigment used for the signature and the lack of density of the superposed coat.


Radiograph. Photograph.

Hand of "Lucretia."

The broad light band running from the upper left hand corner of the radiograph probably indicates the first sketch of the arm and hand, and the extra finger between the middle and forefinger marks the original position of the forefinger.


"Brigands," by C. Sell. (Radiograph.)

"Brigands," by C. Sell. (Photograph.)

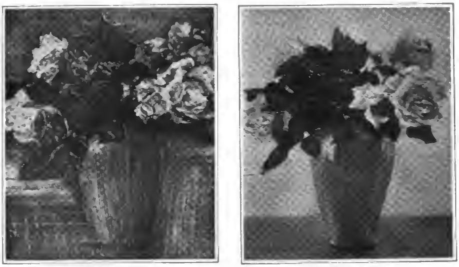
The "Brigands," which is painted thinly on wood, yields little additional radiographic booty. The sky, calm in the painting, is stormy in the radiograph. The grain of the oak panel, clearly visible in the radiograph, accounts for much of the difference, but there are indications of a large white cloud, subsequently painted over.

The two white bands above the head of the robber chieftain were produced by strips of plaster employed to support the panel in making the radiograph. This shows the necessity of cleaning the backs of pictures before they are radiographed.

The radiographs which are here reproduced and discussed illustrate the peculiar value of radiography as a means of identifying oil paintings. The possessor of a radiograph of even a part of a valuable picture, showing the layers of pigment that are hidden from the eye, and the changes made during the composition of the work, can easily distinguish the genuine picture from spurious copies, for it is practically impossible even for an imitator skilled in radiography to make a copy that will stand the Roentgen ray test.

There is another possible inference which I put forward merely as a hypothesis. The radiograph of an original picture usually reveals changes made by the artist in the course of his work. The counterfeiter, like other copyists, reproduces as accurately as possible the final result, which is all that he sees. He also makes errors and corrects them, but his corrections are different from those made by the artist, and serious changes in composition would scarcely be made in the process of constructing a counterfeit. Hence in deciding between rival claims to authenticity, the preference should be given to that picture whose radiograph reveals the greatest and most characteristic changes in composition. It is possible that such disputes, which have continued for centuries in regard to many paintings, can be decided by radiography. The authenticity or antiquity of an uncopied picture may also be decided, apart from the possible detection of a signature, by the radiographic revelation of characteristic methods of working and, in many cases, of characteristic pigments.

It appears, therefore, that the radiographic method, which I have applied with thoroughness to only four paintings, is well worthy of further study and development. In art, as in medicine, it is not an infallible and universally applicable means of diagnosis, and it should be used in conjunction with other approved methods.


Radiograph. Photograph.

A modern flower piece.

The thickly laid on pigments produce very strong contrasts in the radiograph.

New Light on Ancient Egypt

Some of the results of recent exploration in the Nile Valley were described by the Rev. Prof. Sayce, at a meeting of subscribers to the Egypt Exploration Fund at the rooms of the Royal Society.

At Abydos Prof. Naville had discovered the famous temple of Osiris, as he believed, and another colossal monument of Egyptian antiquity had been added to what were already known. It reminded students that the history of Egyptian architecture, as it was known, was one of decadence. Apart, however, from Abydos and the work of Petrie, the chief discoveries of the past season had been made, not in Egypt, but in the Soudan. At Kerma, a little south of the third cataract, Dr. Reisner was changing all accepted ideas of early Soudanese history. He had shown that as early as the fifth and sixth dynasties the northern Soudan was occupied by Egyptian troops, and that trade was carried on from the Blue Nile to the Red Sea, and thence throughout the Orient.

Prof. Garstang, investigating at Meroe, below the sixth cataract, had found an observatory at the bottom of an underground bathing establishment. On the walls were the astronomer's calculations. An African Pompeii had been brought to light. The ruins covered a considerably larger area than those of Memphis, and included a Royal city surrounded by magnificent walls, 15 feet thick in places, with two palaces, public baths, and gymnasia, as well as many streets and private dwellings. The main streets were bordered by trees, for which pits lined with brick had been sunk, and on the riverside walls, quays, and landing stages. The town was the Birmingham and the Liverpool of ancient Africa. It was the center of the iron industry, the smelting furnaces of which had been unearthed, and enough metal was worked there to supply the whole of Northern Africa. Among the most beautiful objects found were cups and bowls of biscuit ware as hard and fine and thin as the egg-shell ware of China, but not translucent. The biscuit ware of China was not older than 200 A.D., while that of Meroe dated from the third or second century before Christ. It was known that the Chinese made trading voyages as far as Abyssinia, and that pottery was among the articles of commerce, so that it was allowable to conclude that they copied the Meroe ware which had been carried by the trade routes to the Red Sea and thence to China.

Lord Carnarvon and Mr. H. Carter had found at Thebes the lost tomb of Amon-hotep. Last year Dr. Borchardt discovered at Tel-el-Amarna the workshop of a sculptor, from which had come the heads of two princesses worthy of being placed side by side with the finest specimens of Greek work. This year the excavations had yielded two cuneiform tablets. One of them was part of a dictionary bearing a list of words in at least two languages. The other was the first example of a political treaty in existence—a treaty between the Egyptians and the Hittites, at the beginning of the Hittite empire. All the discoveries showed that ancient Egypt by trade, war, and diplomacy had relations with the countries around her. The civilized world of the ancient East was not so very much unlike the civilized world of to-day. We stood much nearer to the men of old Egypt than to the half-civilized Europe of the Middle Ages, and we should find ourselves far more at home with them than with the Crusaders who sacked Byzantium.

Lord Grenfell, who presided, recalled the interest taken by the British officers of the Nile Expedition in the remains of the old temples and fortifications. On one occasion he was wrecked on an island in the river, and found most comfortable and hospitable shelter for a day and a night in one of them. He was quartered for two years at Assouan, and it was his good luck to open tombs of the third, sixth, and twelfth dynasties. All Egyptologists were grateful for the support and protection afforded them by Sir R. Wingate, the Sirdar. —*The Daily Telegraph.*

Tractor Biplanes for the United States Army

Conditions Governing a Contest to be Held at the Signal Corps Aviation School at San Diego, California, on or about October 15, 1914

As a result of the $250,000 appropriated for aviation in the army, $30,000 of which is immediately available, the following contest has been announced.

The type desired, namely, a military reconnaissance aeroplane, must possess the following characteristics: Biplane, enclosed fuselage, two seater, dual control, having a maximum speed of not less than seventy and a minimum speed of not more than forty miles per hour when carrying fuel and oil for four hours' flight at seventy miles per hour and a useful load of 450 pounds, and under these conditions of load, being capable of climbing 4,000 feet in ten minutes. All parts of the aeroplane shall be of first-class material and workmanship throughout. The head resistance is to be kept down by avoiding unnecessary parts exposed to the wind, and by using recognized stream lines for those parts necessarily exposed. The power plant is to be located in front of the occupants and suited to the requirements of the aeroplane. The motor must be capable of throttling to 20 per cent of full speed and running without overheating over the land. The motor must be supplied with a positive means of stopping by a short-circuiting device, by release of compression, or by other suitable means. It is desirable that the radiators, if used, should conform to stream line requirements and act as an effective shelter for the motor. The motor should be provided with positively driven pump for pumping gasoline from the reservoir to the service tank and will also be provided with attachments for hooking on a flexible tachometer, the shaft for this purpose to come off the motor at right angles to the propeller shaft, preferably downward. The propeller, or propellers, should be of efficient form and construction and suited for the particular machine and possessing a minimum efficiency of 70 per cent, that is to say, to have a slip of not over 30 per cent. The controls should be of such a type as approved by the Chief Signal Officer of the Army. During the trials, the builder may use such controls as are familiar to his demonstrator, but the Signal Corps design shall be substituted at the builder's expense prior to delivery and acceptance of any machine acquired as a result of this competition. Wear and friction in the control leads must be eliminated in every possible way, and the leads shall be as direct as possible. Leads to pitching and steering shall be in duplicate. The landing gear should be as strong and simple as possible, to be efficient in absorbing shocks in landing and running at full speed over rough and plowed ground. The maximum gliding angle shall under no condition exceed 1 in 6, that is to say, one foot of drop for each six feet of advance. All parts shall be efficiently protected from the action of the weather by the use of suitable paint or furnished with covers. The power plant shall be so arranged as to be readily removed and replaced bodily without disturbing the alignment or the fastenings of the planes or landing gear. The machine complete shall be capable of being assembled from transportation cases in not to exceed two hours by four mechanicians, and of being disassembled and packed in transportation cases in not more than one hour and a half by the same number of mechanicians. No part shall be of such length that when packed the case shall exceed twenty feet in length.

The manufacturers who desire to enter this competition shall inform the Chief Signal Officer of the Army on or before September 1st, 1914, of this fact in writing, and shall supply the President of the Board of Officers, who will conduct the tests, the following data on or before October 1st, 1914:

(*a*) Weight, fully loaded when fully equipped.

(*b*) Normal angle of incidence in horizontal flight.

(*c*) Gliding angles.

(*d*) Safe ranges of angle of incidence.

(*e*) Fuel, oil, and water consumption with certificate of performance (subsequently described).

(*f*) Blueprint or diagram to scale of aeroplane and motor complete.

(*g*) Stress diagram of planes showing tensile and bending stress on beams, struts and brace wires, clearly indicating the material used and the factor of safety in each member, together with moment diagrams.

(*h*) Itemized weight of parts.

The certificate of performance shall consist in a certified test of the motor as follows:

1. One hour run at the rated brake horse-power on the test stand.
2. Half hour run at the maximum power on the stand.
3. A run of half an hour at 20 per cent of the rated revolutions per minute

During the test, the following data shall be reported:

Revolutions per minute at the rated brake horse-power.

Revolutions per minute at maximum brake horse-power.

Minimum revolutions per minute.

The oil per brake horse-power and the fuel per brake horse-power.

A statement of the condition of the motor at the end of a half hour run.

In addition to the above data, the following information shall be noted on the certified test sheet to accompany each motor:

The maker's number, horse-power, stroke, diameter of shaft, piston displacement, type of magneto, type of tachometer used in test, weight complete, starting arrangement, carbureter (trade name), cooling system, lubricating system, type of spark plugs used, date and place of test, the type, pitch, number of blades and blade area of the propeller or propellers used, and if geared down, the ratio of gearing.

The machines entering the competition must be delivered on the ground of the Signal Corps Aviation School, at San Diego, Cal., on or before October 20th, 1914, at the manufacturer's expense. Each manufacturer shall supply a demonstrator. The Signal Corps will provide suitable housing for the machines, and the fuel and oil for the tests. The competitive test will be conducted by a Board of Officers to be appointed by the Chief Signal Officer of the Army under the detailed rules which are given below.

To enter the competition, each machine must qualify by demonstrating by actual trial that it complies with the above requirements by making a non-stop flight of four hours in the air, and by making the climb, fully loaded, of 4,000 feet in ten minutes. The machines will be graded by points, taking into consideration the following:

Construction and workmanship; speed, maximum and minimum; climbing and maneuvering ability; ease of handling; gliding angle; inherent stability; suitability of landing gear, distance of run on the ground when starting and landing; field of vision, etc.

If five or more machines qualify, the Signal Corps will purchase the three which make, in order, the greatest number of points; the first for $12,000, the second for $10,000, and the third for $8,000. If but three or four qualify, the first two will be purchased at $12,000 and $10,000, respectively. If but two qualify, the one making the highest number of points will be purchased at $12,000.

All inquiries concerning this competition should be addressed to the Chief Signal Officer of the Army, Washington, D. C.

THE GENERAL RULES AND SCHEDULE OF POINTS FOR THE COMPETITION FOLLOW:

All tests shall be made with a pilot, passenger, and sufficient dead load to make the total of 450 pounds of useful weight in addition to fuel and oil sufficient for 4 hours' flight.

All tests will be made at times to be specified by the Board.

Air-brakes, means of locking wheels, etc., will be allowed in all landing tests.

All landings shall be made normal.

In the speed tests a practically uniform height above the ground must be maintained by pilot from the time he crosses the starting line until after he passes the finishing line

In case a competitor takes his full number of trials he will be given credit for the best performance, not the average of the trials.

Any questions that may arise which are not covered by the above will be determined by the Board of Officers conducting the test, whose decision shall be final.

No.	Point.	Required	Value	How determined.	Number of trials allowed	
1	Construction and workmanship.	..	200	Practical examination by Board study stress diagrams, etc.	.....	
2	Speed, maximum	70 M. P. H.	100	Over measured course three flights each way.	3	For speeds in excess of 70 M. P. H. additional points will be given at rate of four points per mile over.
3	Speed, minimum	40 M. P. H.	100	Over measured course three flights each way.	3	For speeds below 40 M. P. H. additional points will be given at rate of two points per mile under.
4	Climbing	4,000 feet in ten minutes	100	Flying start, competitor to fly parallel to ground and close to it before attempt.	3	For each 100 feet over 4,000, covered in 10 minutes climb, competitor will be allowed 5 points additional.
5	Suitability of landing gear ...	.....	100	Maneuvering on ground under power, starting from and landing in plowed and rough ground	....	Best machine will be given perfect score, others rated accordingly.
6	Gliding angle	Minimum 1 in 6.	75	After flying level at specified height competitor will cut engine out at given signal and descend in given direction.	3	Ten points for each additional foot in excess of that required, namely, 6 feet of advance for 1 foot descent.
7	Inherent stability.	....	75	Theoretically and practically.	.....	Best machine will be given perfect score, others rated accordingly
8	Ease of maneuvering in air ...	... .	50	The Board will prescribe certain evolutions to competitors.	.....	Best machine will be given perfect score, others rated accordingly.
9	Field of vision. ..	.. ...	50	From practical observation of military observer.	.....	Best machine will be given perfect score, others rated accordingly.
10	Ease of assembly...	2 hours, 4 men.	25	Practical test on field.	.....	Best machine will be given perfect score, others rated accordingly.
11	Ease of disassembly	1½ hours, 4 men.	25	Practical test on field.	....	Best machine will be given perfect score, others rated accordingly.
12	Ease of installation and repair motor, etc.	....	25	Practical test on field.	....	Best machine will be given perfect score, others rated accordingly.
13	Landing over 30 foot obstacle and pulling up in field beyond. ..	.. ..	25	Practical test on field	3	Best machine will be given perfect score, others rated accordingly.

Iron Shielded from Earth's Magnetism

In the *Proceedings* of the Royal Society an account is given of experiments made by E. Wilson on a ring specimen of stalloy built up from stampings and a magnetic shield formed from stampings of transformer iron. The specimen was supported symmetrically within the shield, and the common axis placed at right angles to the magnetic meridian. Measurements taken ballistically with the ring shielded and unshielded show that the earth's magnetism may seriously affect the magnetizability of iron.

Comparing the results obtained when stalloy was magnetized and then demagnetized, with the results of similar experiments on the same material demagnetized but exposed to the earth's magnetism, the ratio of the permeabilities had a maximum of 1.79 when B was 172, and the ratio of the maximum permeabilities was 1.24. The maximum μ for the shielded specimen was 5,900. The dissipation of energy by hysteresis was less when the stalloy was demagnetized in the shield than when demagnetized and then exposed to the earth's magnetism. The Steinmetz index, after rising to a maximum of about 3 for a force of about 0.008 C.G.S., begins to diminish as the force is reduced, and at about this point the hysteresis loops tend to become parallel straight lines.

The Pinnacle of the Canadian Alps

The Opening of a New American Scientific Storehouse

By Carl Hawes Butman, Smithsonian Institution

FOLLOWING the much reiterated slogan of American railroad and steamboat lines, "See America first," it seems pertinent to extol the characteristics of a part of this continent only recently explored, but in the near future to be opened for the inspection of its scenic wonders, comprising mountain ranges, peaks, glaciers, rivers, lakes, and waterfalls of exceptionally wild grandeur and romantic beauty. There are features which are calculated to surprise and interest even the most *blasé* tourist, scientist, or artist. The region referred to is that portion of the Rocky Mountains lying, unfortunately, just outside our border, in the territories of British Columbia and Alberta, Canada, and known as the Robson Peak District.

The majestic mountain from which this district takes its name, originally called Robson Peak by Milton and Cheadle in 1865, but later designated Mount Robson, has now been renamed Robson Peak by Dr. Charles D. Walcott, secretary of the Smithsonian Institution. It stands in the very heart of a severely cold and rugged country unbroken by trail or blaze, amid the most vivid and diversified natural scenery, surrounded by a number of massive, though less lofty, mountain ranges and peaks, and thrusts its rocky spire upward through glaciers, icefields, and even the clouds, to a height of 13,068 feet above the sea. Although it is only about eighth in height in America, it is the highest point on the Continental Divide in Canada, and has been aptly termed "The Monarch of the Canadian Rockies" by Dr. Walcott in both his descriptive and technical reports upon his investigations in this locality.

This gigantic peak is located thirty-two miles west-northwest of Yellowhead Pass on the Continental Divide, and just six miles north of Fraser River and the Mount Robson station on the Grand Trunk Pacific Railway. It locates the center of a section of Canadian territory twenty miles in diameter, which is soon to be opened to explorers and travelers. One gateway to this veritable wonder-land is already open from Edmonton, Alberta, *via* the Grand Trunk to Mount Robson station, which affords the sightseer a view of the Peak itself, only six miles distant. Already Robson, with its approaches, has been roughly explored and mapped by the Alpine Club of Canada, which plans to establish its next summer camp at the foot of Robson on the shores of Berg Lake, in the clear and cool atmosphere attending a 5,500 foot elevation. Soon, undoubtedly, it will be no uncommon sight to see many tourist parties tramping over the great ice fields and scaling the stony mountain sides, for it is thus, practically in a night, that the American recreation and outdoor loving populace seize upon opportune moments to be early on the scene of a newly opened playground.

Robson Peak was virtually unknown, except to a few venturesome hunters and trappers, until about 1909, when Dr. A. P. Coleman wrote a graphic description of its grandeurs and related his attempts to scale its scarcely pregnable ramparts, although as early as 1865 Milton and Cheadle, two English explorers, made mention of it in their article, "The Northwest Passage by Land," and later McEvoy and Kinney told of this great Canadian peak and the country surrounding it.

Others have since visited the region and have also attempted a description of this ice and snow clothed mountain and its remarkable and wonderful Alp-like environs, but like most of those who have essayed to chronicle the virtues of the Grand Canyon of Arizona, they have failed; it is well nigh impossible to do such scenery justice.

One of the most inspiring and spectacular scenes in the world may be witnessed from the slopes of the peaks and mountains surrounding Robson, particularly from a great ridge south of Mumm Peak at an elevation of about 1,800 feet above Robson Pass, where an extensive view of what is termed the Robson massif may be gained. Directly opposite protrudes a great monument of solid barren rock called Iyatunga (black rock), and just back of this Robson towers, a veritable pinnacle of the world, its rocky cliffs 7,000 feet from the shores of Berg Lake rising to the summit where gather daily the mists and rain clouds from the Pacific to be condensed into snow and ice, thus adding constantly to the deep snow banks and wide ice-fields which form a perpetual crown for this regal peak, and make possible the several giant glaciers. Down its eroded sides sweep three of these rivers of solid ice. The largest and longest of them, Hunga, formerly Robson Glacier, but renamed from the Assiniboine Indian word for chief, is formed in the *névé* between Robson Peak and Mount Resplendent. From there it swerves to the northwest, encircling the base of the peak with its chill arm, and glides sedately between Iyatunga and Titkana (bird peak), not unlike a polar giant's stairway descending in a slow, graceful spiral through these two mountainous newell posts, a distance of over three miles, to where it breaks up in the pass below. Of the two other glaciers to the southeast, both of which slide more directly into the lake, the nearer one, Blue, is the more attractive feature, on account of its nearly head-long drop of over a mile from the icy crest of the Peak to the lake shore, where its great ice sheet, now fully two miles in width, is dismembered into small bergs which float away. Blue Glacier, literally a sparkling, frigid river of bluish ice, hangs, apparently suspended by some strange force, ready to fall *en masse*, at any moment from its precipitous bed. The other, Chupo (Mist) Glacier, scarcely visible in its envelope of clouds and mist, though not so remarkable for its beauty and size, proves of great geologic value; it bears on its surface and in its icy grasp many fossiliferous rocks dragged from the top of the mountain to the moraine below, which frequently contain interesting fossil specimens in the form of marine shells and fragments of crab-like animals of the so-called Ordovician time. Beyond the glaciers, far to the southeast, is the Miniohan mountain range, which lends perspective to the scene by forming a distant horizon, while on the northwest, Titkana, once known as Ptarmigan Peak, frames the picture with its high, rocky slopes.

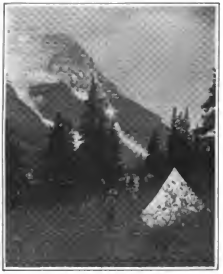


Fig. 1.—A view of Robson Peak, the pinnacle of the Canadian Alps. Spring in the valley and winter on the mountain. Photo by Mr. R. C. W. Lett, Grand Trunk Pacific Railway.

Just three and one half miles north-northeast of Robson the Continental Divide runs from Yellowhead Pass irregularly to the northwest, passing between Lake Adolphus and Berg Lake. On a rocky projection near Titkana Peak, the water from the Hunga Glacier divides; one stream turns to the northwest to Lake Adolphus, into the Smoky River drainage of Alberta, thence through the Peace and Slave Rivers to Great Slave Lake, and north *via* the McKenzie River into the Arctic Ocean; the larger stream flows southwest into Berg Lake, from there over Emperor Falls into Grand Fork and Fraser Rivers, and eventually to the Pacific Ocean. It is possible to stand on a certain block of ice on the Hunga Glacier and watch the water running over its surface divide, on this very block, and flow, one branch to the Pacific and the other to the Arctic Ocean. One experiences an odd sensation, thus to stand, as it were, on the ridge pole of the continent, where the future course of a floating chip or other object may be determined by a slight movement of the observer's foot or hand, causing it to take either the right or left hand branch.

To this Canadian alpine district, Dr. Walcott makes summer trips for the continuance of his investigations and studies in the comparison of the section of Cambrian rocks there, with that of the line of the railway, one hundred and fifty miles to the south.

Outfitting at Fitzhugh, a small town on the Grand Trunk Pacific, last summer's party crossed the Continental Divide over the Yellowhead Pass and turned north from the railway at Moose River, seventeen miles west of the pass. From this point they followed the course of the Moose River to its source in the pass of that name, making several stops *en route*, and encamped at the head of Calumet Creek, a tributary of the Smoky River. The camp farthest out, the final one, was at Robson Pass between Berg Lake and Lake Adolphus, from which several side trips were made.

Besides carrying out the main object of the expedition, that of securing specimens of the various fossils from the localities visited, and making a general reconnaissance-section of the great block of Cambrian and Ordovician strata from which the mountains of this region have been formed by uplift and erosion, Dr. Walcott found opportunity for making many fine photographs, especially panoramic views showing the geological formations, while Mr. Lett photographed a number of unusually striking and picturesque scenes in this neighborhood. Through the courtesies of these gentlemen, several photographs are herewith reproduced.

The summer's observations and measurements extended the geological section from Moose Pass southwest over Tah Peak, Mount Mahto, Titkana Peak, and across, by way of Phillips Mountain and the ridges of the Lynx Mountains, including Billings Butte, to Robson Peak. By air line, the actual distance was only nine and one half miles, but the course followed was necessarily a very irregular one, since it was only possible to examine the exposed sections free from snow fields and glaciers, and consequently covered a great distance. It was found that the depth of the stratigraphic section examined was approximately 12,000 feet of Cambrian rocks and 3,000 feet of Ordovician; the transition between the two systems being in Billings Butte, which projects upward near Hunga Glacier.

Many fine specimens of a new sub-fauna of the Lower Cambrian series of rocks were located by Dr. Walcott at the northern base of Mumm Peak above Mural Glacier, which will add materially to the National Museum collections, already well advanced by his extensive contributions.

Undoubtedly the work of Dr. Walcott in this vicinity, and generally in the Canadian Rockies, has done more toward the advancement of human knowledge in invertebrate paleontology, especially as regards the Cambrian life, than that of any other student of similar researches. His prime object seems to be the true one of advancing the knowlege of geology and paleontology of this district, generally and not solely through his own researches. In this respect many of his photographs are taken with a view of enabling future explorers and scientists to recognize the localities and the general positions of the formations he has discovered. Further than this, he has revised, to a certain extent with the approval of the Canadian Board of Geographic Names, the nomenclature of many points of general and particular interest, making their locations and designations clearer by labeling his wonderfully detailed panoramic views, thereby happily tying art and science. In a recent Smithsonian publication he states with modesty, that although he was not the original explorer of this district, it fall to his lot to be the first to make a study of the geologic section, and this necessitated the application of additional names in locating, describing, and designating the geologic formations.

Two members of the party devoted their time to zoological collecting, and secured a number of mammal skins and skulls for the National Museum, thereby increasing the earlier collections obtained in this region by the Smithsonian Biological Survey party which accompanied the Alpine Club on the topographical survey in the summer of 1911.

With the completion of the railroads and the continuation of scientific researches, with the resulting literature of both, there is little doubt that the Robson Peak District will be well advertised, or that this high, cool, clear-aired portion of the country will remain long unknown and unvisited by the tourist, the vacationist, and eventually the home-seeker.

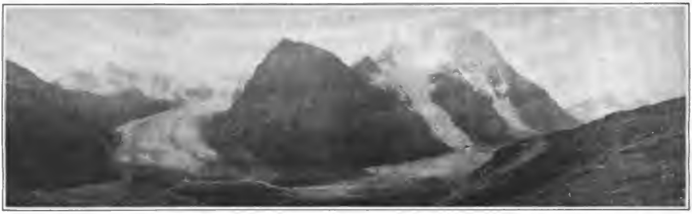


Fig. 13.—Robson, from a point on the south slope of Mumm Peak; Robson Peak to the right of the center; Hunga Glacier flowing into Robson Pass from between Titkana and Iytanga Mountains; Blue and Chupo Glaciers on the right, gliding directly into Berg Lake. Photo by Dr. Charles D. Walcott.

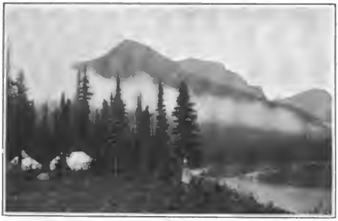


Fig. 2.—A misty day at Camp A, on Hihuna River above its junction with the Moose. Photo by Mr. R. C. W. Lett, Grand Trunk Pacific Railway.

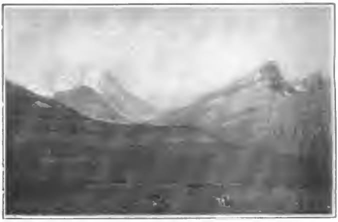


Fig. 5.—On the slope of Mahto Mountain; Robson and Mumm Peaks in the distance. Photo by Mr. R. C. W. Lett, Grand Trunk Pacific Railway.

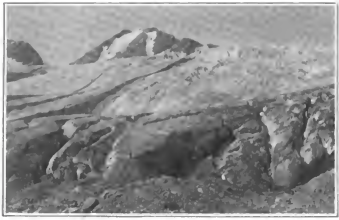


Fig. 8.—An unnamed glacier above Moose Pass and below Calumet Peak. The three men on the glacier give an idea as to its size and extent. Photo by Mr. R. C. W. Lett, Grand Trunk Pacific Railway.

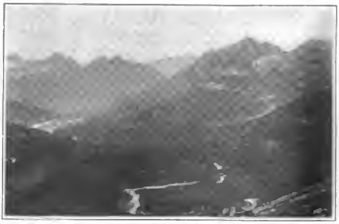


Fig. 9.—Looking down through the Valley of Flowers, toward the first camp in Calumet Creek. Photo by Mr. R. C. W. Lett, Grand Trunk Pacific Railway.

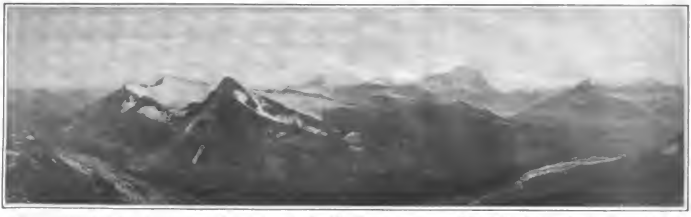


Fig. 15.—Looking down into Calumet Creek; Tah Peak in the center above Moose Pass; to the right Lynx Mountain; Robson Peak, above Berg Lake; and Mumm Peak showing Mural Glacier. Photo by Dr. Charles D. Walcott.

THE PINNACLE OF

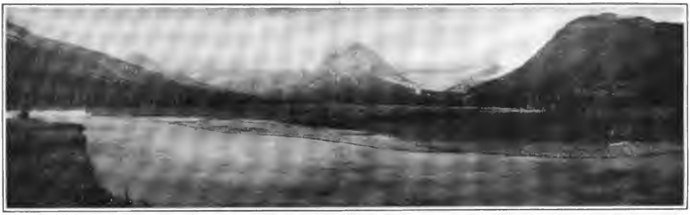


Fig. 14.—Looking south across the flats of Calumet Creek; Tah (Moose) Peak is in the center, with Moose Pass below at the left, and Mahto (Grizzly Bear) Mountain is seen on the right. Photo by Dr. Charles D. Walcott.

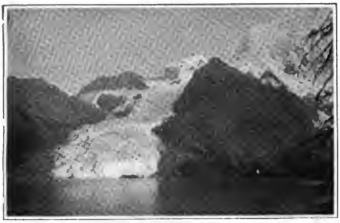


Fig. 6.—Dreamland, at the foot of Robson; Blue Glacier and Berg Lake. Photo by Mr. R. C. W. Lett, Grand Trunk Pacific Railway.

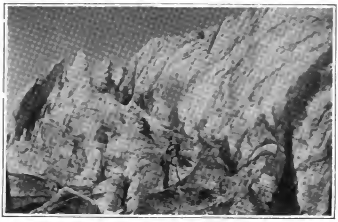


Fig. 7.—Climbing Alpine fashion over the ice-foot of the Hunga Glacier. Photo by Mr. R. C. W. Lett, Grand Trunk Pacific Railway.

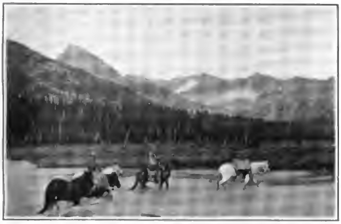


Fig. 12.—Dr. Walcott and party crossing Calumet Creek. Phota by Mr. R. C. W. Lett, Grand Trunk Pacific Railway.

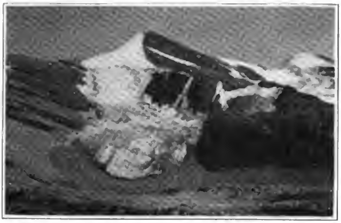


Fig. 17.—Phillips Mountain with Cushlaa Glacier extending a mile down its west slope. Photo by Dr. Charles D. Walcott.

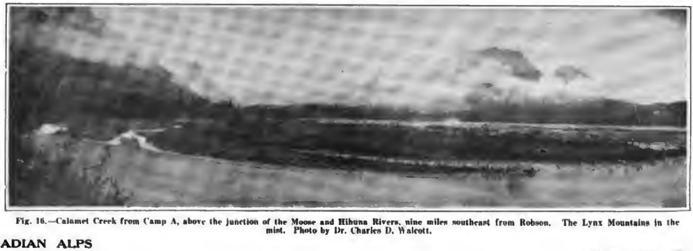


Fig. 16.—Calamet Creek from Camp A, above the junction of the Moose and Hibuna Rivers, nine miles southeast from Robson. The Lynx Mountains in the mist. Photo by Dr. Charles D. Walcott.

E CANADIAN ALPS

American Opportunity in a World Catastrophe*

Will We Profit by Past History?

By Harrington Emerson

Act, although unprepared! Act wisely! The national opportunity of a millennium is ours. Shall we of the United States be found as ready and as courageous as is Germany? Our courage, our wisdom, should be for peace, for advancement, not for destruction of civilization.

Great opportunities come as rarely in the life of nations as in the life of an individual. If the moment is missed it never returns. Such an opportunity came to Japan in the seventeenth century. Her junks were navigating everywhere in eastern Asiatic waters; they had crossed to the North American coast, and hers it was for the taking. Spain, Russia came a hundred years later, England the United States one hundred and fifty years later. Instead of seizing the new world to the east open to her, even as France, England, Spain, and Portugal seized the new world to the west, open to them, Japan destroyed her mercantile marine and deliberately turned her back on the sea.

France similarly did worse than miss world opportunity. She forfeited what she had already attained. Canada and all the Canadian Hinterland was hers, Louisiana and all its northwestern extension was hers. She let it go!

Spain at one time possessed the new world by right of discovery from Florida to Patagonia and she lost it all.

England by a little common sense might have guided for a while then have been federated with what is now the United States.

Each of these countries at the critical moment faltered and failed. Shall we of the United States, when our great opportunity comes, falter and fail, or shall we set a mark that it will keep us busy a hundred years to attain?

There are eight great powers in the world. In the order of their population they are found to rank as follows:

British Empire,
Chinese Republic,
Russian Empire,
Great American Republic, the United States,
French Republic,
German Empire,
Japanese Empire,
Austrian Empire.

To-day six of these great world powers are embroiled in war—three, aided by three or four smaller powers, against two; Slav, French, England, Portuguese, possibly Japanese and Italy, arrayed against the Teutons!

The Chinese Republic is torn by internal strife and for the moment does not count. The United States, owing to the peace and justice-loving efforts of a great President, is not embroiled in any war with Mexico. The United States stands alone—able, if we have the courage and ability, to push forward civilizing ideals and that financial and industrial supremacy to which each modern nation legitimately aspires, a supremacy that makes for leadership.

We are unprepared! As colonists and as a nation we have rejected all the traditions and fundamentals of great organizations and great policies. Those fundamentals are definite ideals, permanence of executive authority, persistence of policy, accumulation and utilization of past experiences, authority commensurate with responsibilities. The United States in its growth is not a creation; it just happened and is still happening; but the time has come to stop happening and to look ahead and act, not for the moment, but for all time.

The greatest of all wars that the world has ever seen has been brought about by ideals—ideals not of expansion through civilization, but of expansion through conquest.

Ever since the time of Peter the Great, ever since he wrested the shores of the Baltic from Charles of Sweden, the shores of the Black Sea from the Turks, ever since Bering dragged overland from Moscow the boat he launched in Pacific waters, Russia has aspired to an outlet on unfrozen seas. In land conquest and land absorption she has steadily realized her ideals. Russia, in land area, has grown more rapidly and more recently than our thirteen colonies; but toward the sea she has been thwarted. By combinations in Europe she was bottled in the brackish, shallow, frozen Baltic. England and France by war bottled her into the Black Sea, and European concerts have repeatedly since stopped her march on Constantinople. Towards the west (although Vladivostok is as far south as the semi-tropical southern coast of France, it is nevertheless frozen in through the winter), the Japanese wrested Port Arthur and Manchuria from her.

Kuropatkin, the great Russian general of the Russo-Japanese war, bitterly deplored this activity of Russia in the far east. "Our danger lies on our western border," he said. "We are playing into the hands of our enemies." And so it has proved.

Austria also, and behind Austria, Germany, are both determined to expand by conquest. These nations believe that trade follows the sword, and that race and nationality are more important than civilization. So Austria and Germany are determined to control the Balkan peninsula, to possess Constantinople, to occupy and develop Asia Minor and old Assyria and Babylonia.

England always had oversea land-hunger, and while the other nations were still asleep she appropriated almost half of North America, all of Australia, a large portion of Africa from Cairo to the Cape, the choicest part of southern Asia; and as part of her policy, starting with the north side of what she calls the English Channel, England also appropriated the strategic parts of the ocean, as Gibraltar, the Suez Canal, Aden, Cape Town, the Malacca Strait, the north of the St. Lawrence and the north shore of all the American Great Lakes, and the north shore of the Straits of Juan de Fuca.

England failed in her ideals when she drove the colonies into rebellion, and under Lord Palmerston she most surprisingly overlooked the opportunity to take over the whole of equatorial Africa and to annex southern Patagonia with the Straits of Magellan.

France, which let North America slip out of her grasp, has for centuries held to utopian ideals of glory and of balance of power in Europe. At this distance we cannot sympathize with the long wars of the Spanish succession, nor with France's wars with Russia, with Austria and with Germany under Louis Napoleon. They weakened France and they unified Germany.

Since the Burgrave of Nürnberg lent money to the Emperor Sigismund and took in pledge the borderland of Brandenburg, the wonderfully thrifty, ambitious, persistent, courageous, and industrious Hohenzollern rulers have aggrandized their dominion—from county into electorate, from electorate into kingdom, from kingdom into headship of North Germany, from headship of North Germany into imperial leadership of all Germany.

The Hohenzollerns have not overlooked any opportunity to advance the one ideal of dominating expansion, and they have persistently used all the fundamentals of organization. The warlike ideal, however, has been largely forced upon Prussia. Russia, Austria, and France all combined against Frederick the Great, and it was only by very great ability as General and King that he saved Prussia from the fate of Poland. Prussia was beaten to a finish and partly dismembered by Napoleon. In 1866 there was a German coalition against Prussia of nearly all the other German States, including the Austrian Empire. It was only by stupendous Bismarckian skill in diplomacy and von Moltkean skill in military organization and strategy (both being supported by the old King, wise in the tradition of his house) that Prussia emerged triumphant; and such a triumph!

On June 14th 1866, Bismarck laid before the German Diet, a Prussian plan for the settlement of the Holstein-Schleswig question, and threatened with loss of existence any small German State which should vote against Prussia. Nevertheless he was voted down, and *the next day*, June 15th, the Prussian armies invaded Saxony and Hanover. On July 3rd, the decisive battle of the war was fought; and peace soon followed, the terms being that Prussia got all it wanted. The coalition Prussia attacked had twice the land area and twice the inhabitants of Prussia, but it proved no match for Prussian skill.

Prussia never vacillated. In 1864 England and France vacillated as to the protection of Denmark, thus allowing Prussia to acquire Holstein, and later to build the Kiel Canal, which makes the Baltic a German harbor.

In 1866 France vacillated, was not ready, allowed herself to be coaxed by veiled and non-specific promises of compensation. In 1870 France played into Bismarck's and Von Moltke's hands by losing her head over the Spanish throne incident. Germany was ready, and Bismarck knew it; France was not ready, and Bismarck knew that also. Austria expected to help France; but war was declared so suddenly, July 15th, 1870, the Germans mobilized so much faster than the French and were in French territory in three weeks, that the Austrians lapsed into quiescence. Germany was strong enough and ready to fight both France and Austria. I personally saw Germany go into that war.

I shall try to give Americans some idea of the German war game. Did you ever see an American circus mobilize, break camp, move and set up again? It is one of the most wonderful examples of efficiency we have produced. The great tent city is in full swing at 10 P. M. The next day at 10 A. M. it is parading the streets of a town a hundred miles away. The German army mobilizes and moves like an American circus in the height of the season.

Did you ever see a major league game of baseball played? There are the rules of the game, there is the coaching of the outs, there is the outer fielder, for instance, who knows the rules, listens to the coach, but has his eyes, legs, and hands ready for any batted ball that comes his way. When he is running for a catch other things had better get out of his road. These are the German tactics—perfect organization, the rules understood by all, the team drilled to act as a unit, yet each unit able, competent, and instructed to act on his own initiative in his own region. But the German game is played with 2,000,000 players on a side.

Did you ever see an American fire department answer the gong and hurry to a big fire? They stop at nothing and for nothing. Everybody else gets out of their way. Trolley cars stop, horses and vehicles line up along the curb, pedestrians clear the streets. The fire department is rushing into war with fire, and well it knows the value of seconds and of hitting hard and strong. That is the way the German army goes into war, which suddenly becomes the one supreme business. Civil rights there are none any more. You sit up and take notice that war holds the center of the stage as well as the wings.

Did you ever consider the wonder of the weather bureau service? Every morning your paper tells you what the weather will be for the day. The facts were gathered over the whole broad expanse of North America, were wired into Washington, there analyzed and interpreted, and the warnings sent out. It all has to be done in a few hours. By a system similar in its completeness the German general staff knows what is happening everywhere all the time. Before dawn the following day, Von Moltke knew more about the battle of Gravelotte—a widely extended battle, which continued until after dark—knew more of the position of the various troops and their condition and availability for further action, than we know now about the battle of Gettysburg.

Owing to the baseball organization of the Prussian army, owing to its circus-like mobilization and movement, owing to its fire-department suddenness and energy, owing to the perfection of its information, seven weeks after war was declared in 1870 the war was practically ended by the surrender of the French Emperor and his army and the bottling up of Bazaine and his army at Metz.

Out of the ashes of the war of 1870 the German Empire arose, North and South Germany united, and augmented by the annexation of Alsace-Lorraine; Russia and England held aloof, triumphant Germany was strong enough to oppose them both.

I do not like the Prussian ideal of conquest, annexation, as a means of extending German civilization. Belgium, Holland, Switzerland were prosperous, without lust for expansion, and the United States believes there is more for both countries in aiding Mexico than in conquering her. Nevertheless, holding as her chief ideal offensive wars of aggrandizement, the German army lives up to the ideal. It declares war with instant suddenness, it mobilizes almost over night, and it strikes first and hard.

Germany has this time only repeated on a larger scale what Prussia did in 1866, what the German Bund did in 1870. Holding to the ideal of expansion, Luxembourg, Belgium, Holland, Switzerland as possible prizes if they dared stand in the way, another slice of France, Russian Poland, perhaps Finland, the incorporation of German Austria and Hungary in the empire, unlimited expansion toward Constantinople, toward Bagdad and beyond—why not strike immediately before Russia and France and England became any stronger? If the Germans succeed there will still be a Russia, still be a France, still be a Great Britain, even as there was still an Austria after 1866, still a France after 1871.

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* *The Engineering Magazine.*

If Germany fails there will still be a great Germany, pushed back perhaps to the Rhine, rectifying perhaps the Russian frontier, but with Oriental dreams shattered, and with the Slav holding the Balkans.

How long will the war last? David Starr Jordan is quoted as saying it will cost $50,000,000 a day; already $5,000,000,000 have been voted to be spent, in addition to the immense war chests and war supplies already on hand. The casualties to date show a loss of life exceeding 3,000 a day. The war is not likely to last over six months.

What is the outlook for America? For your neighbor's house to be on fire is never a good thing for you. On the contrary, we want our neighbors to be ten times as prosperous as they are so that we can sell more to them. Impoverished neighbors cannot buy our products, and that will affect all business adversely. Nevertheless the South African war stimulated the mule market in the United States, and wheat and corn have already risen in price.

While the great destruction is on, and when it is over, Europe will need our accumulations, and will not only pay an enhanced price for them, but will pay with our own best securities at greatly lowered prices. Thus doubly will Europe be made tributary to us. But it is never in the long run advantageous to take your neighbor's capital.

The war must be short, and marvelous is the recuperative power of combatants. Men of arm-bearing age are, as a rule, only 5 per cent efficient; the average is rather less than this compared to the best, 100 per cent, the picked few who are in all respects sound. A very little absolute improvement in efficiency might double the average. Other great wars have this effect on a people. They climb out of their ruts, they break away from tradition.

There was a great up-swing in the United States after 1865, in Germany after 1866, in France and Germany after 1871.

The destruction of war is not nearly as great as it seems. If people do not produce, neither do they consume, and the man who may have been making and spending $10 a day, comes down to the $1 or even to the $0.10 level without particular detriment either to himself or to his similarly placed neighbors. The total wealth of Germany is $80,500,000,000, and even if the actual war wastes were $2,000,000 a day, this in a whole year would amount to less than 1 per cent of its accumulated wealth.

The average death rate in Germany is probably 20 per thousand, or 1,200,000 a year. Kill a million soldiers and you have only doubled for one year the normal outflow. In four years, if the normal rate were lessened from 20 per cent to 15 per cent, the loss would be numerically made up. The loss of life, the loss of time, the loss of property in a six months' war is, after all, insignificant compared to the great enduring life of the nation. Recuperation will be rapid.

If business is not to be immediately boomed in the United States, if Europe is rapidly to recuperate whoever wins, what legitimate advantage is in store for us? The American ideal is not one of war, but of peace, and in so far as that ideal is better for humanity, it is well that American influence shall be extended through the world.

Are we unprepared? Have we no policy? Are we to drift? Is the stupendous opportunity to be forfeited?

Our currency bill has been passed, giving us almost unlimited ability to expand financially. South America has been financed by England and Germany. It is our opportunity to finance our American neighbors and to reap the reward of the patient policy as to Mexico. Are we wise enough to meet the expectation?

The Panama Canal is completed and the west coast of South America is at our doors, ready to extend us a hearty welcome.

The mercantile marine of the great powers is flocking to our flag, where it ought to stay. Are we wise enough to secure it, and to expand it?

The nations of the world are taking over the home supplies lest there be a shortage. Is our Government wise enough to see the need of taking over the cotton crop, the wheat crop, the corn crop, and a number of other staples, at a normally high price, holding them until the world needs them and must have them?

I believe that every individual should do all he can for himself up to the limit of his capacity. He should be a doer. Beyond that capacity begins the normal function and responsibility of the corporation. The State's duties begin where those of the corporation reach their limit. The southern farmer has raised all the cotton he knew how to, probably not more than half of what he ought to have raised per acre. Corporations have ginned it for him and compressed it and stand ready to haul it to market. No corporation can buy and hold the whole cotton crop or any part of it. It is the duty of the Government to place in reservoir the flood of the unmarketable cotton and to hold it at a minimum export price until wanted.

Here there are great national possibilities and policies for which we need the power of the Government:

First—To assure such currency facilities as will enable us to buy back our investment securities at the low price at which they are offered.

Second—So to assist our banks as to enable us to finance the world's colonial trade which the warring nations are dropping.

Third—To take over the mercantile marine of the world so as to carry our supplies to those who either now or later will so urgently need them.

Fourth—To take over and hold until needed the export staples of the country, especially those temporarily depressed. Shall our farmers sell cotton at half price now, when before the next crop is gathered it will command a war price?

Great lines of peaceful expansion and growth are, in this great catastrophe, ours for the taking. Never was there such an opportunity before, and let us hope that it will never come again.

We must act now, or forever regret.

Marine Birds and Hydro-Aeroplanes

The Director of the Laboratory of Aviation in the French École des Hautes Études, Dr. Magnan, has made a minute study during the past five years of the characteristics of sea-birds, with the object of deducing principles therefrom which might aid in the perfecting of aeroplanes. He has rigorously calculated the wing-surface, the weight and width of the wings, their spread, and the total length of many hundreds of birds, taking careful note in each case of the mode of flight. He has observed that the various relative dimensions were practically constant for the species of the same group of birds practising the same sort of flight.

Thus, all the birds of prey flying by day have practically the same wing-surface, the relation of their wing-spread to the length of the body being constant. On the other hand, these dimensions differ considerably when different groups of birds are considered, as birds of prey, marine palmipeds, and birds of passage.

At a recent meeting of the French Académie des Sciences, an account of Dr. Magnan's researches was presented by M. Ed. Périer, who said:

"In investigating the characteristics of marine birds (palmipeds) he has been able to define them thus: The marine palmipeds possess the greatest relative wing-spread found among birds of any kind, on the other hand, they have the narrowest wings. Their wing-surface is very large, but less, however, than that of the predaceous birds. The tail is considerably abbreviated, but the total length is nearly the same as that of the birds of prey, in spite of this shortening of the tail. The relation of the wing-spread to the width of wing is greater.

"M. Magnan shows also that the narrowness of the wing and the shortening of the tail seem to be the result of an adaptation to flight in the great currents of air, since all the water birds (ducks, small wading birds) which fly in analogous conditions also have narrow wings and short tails.

"M. Magnan had already proved by his study of soaring birds that it was possible to make a practical application in aeroplanes of the dimensions discovered by him in birds. The Ponnier monoplane piloted by E. Védrines in the Gordon Bennett Cup Race of 1913, contained both the first application and the justification of his researches. The fuselage of this monoplane possesses characteristics which are absolutely individual; it presents, in accordance with the results of M. Magnan's observations, the lowest proportion of total length to wing-spread. This reduction of the fuselage permits very rapid leaving of the ground, and seems to give a superior ascensional speed, since, in the cavalry type of avion, Bielovucic has attained a height of 1,500 meters in 5 minutes.

"M. Magnan has calculated the dimensions of a monoplane modeled after marine birds, as well as those of the soaring machines, which copy the birds of prey. His figures, in a machine weighing 400 kilogrammes in flying order, are as follows:

"Wing-surface in soaring monoplane of the bird-of-prey type equals 12.60 square meters; and 10.20 square meters for the monoplane of the marine-bird type.

"Weight of wings, 78.800 kilogrammes and 77.800 kilogrammes, respectively.

"Wing-spread, 9.78 meters and 10.30 meters, respectively.

"Width of wing, 1.69 meters and 1.25 meters, respectively.

"Length of tail, 1.90 meters and 1.32 meters, respectively.

"Length of machine, 4.34 meters and 4.26 meters, respectively.

"It will be seen that there are very noteworthy differences between those two types. It may be that builders will be inspired to make use of these conclusions, either in total or in part, in the construction of hydro-aeroplanes."—*L'Aerophile.*

A Fossil Human Skeleton from German East Africa

By George G. MacCurdy

At a meeting of the Gesellschaft Naturforschender Freunde, in Berlin, on March 17th, 1914, Dr. Hans Reck made a preliminary report on a discovery that is of special interest to anthropologists. Dr. Reck was attached to a geological expedition that had been sent out to survey a parallel running through the northern end of German East Africa, as well as to collect for the Geologic-Paleontologic Institute of the University of Berlin and the Paleontological Museum at Munich.

The discovery in question was made in Oldoway hollow or gorge on the eastern margin of the Serengeti steppe. The Oldoway gorge lays bare a series of tufaceous layers that had been deposited in a fresh water lake. Five deposits can be distinguished stratigraphically as well as paleontologically. In the lowest deposit fossil remains are rare, the chief specimen being a part of a rhinoceros skeleton. The second deposit is rich in fossil mammalian remains, including the human skeleton. Remains of two types of fossil elephant, both different from the living *Elephas africanus*, were especially abundant; the skull of a hippopotamus was also found in deposit number two. Bones of the antelope appear for the first time in the third deposit, which also contains bones of the elephant. Elephant remains are dominant in the fourth deposit; fish bones are also abundant. The fifth and latest of the deposits is the richest of all in fossils. It is characterized by an antelope and gazelle fauna similar to that now living on the Serengeti steppe. In this deposit Reck found no elephant remains.

The change in fauna represented by the series corresponds to a change in climate. The climate of the upper horizon was similar to that of to-day; while the elephant, rhinoceros, hippopotamus, crocodile, and fish of the lower horizons bespeak a damp woodland climate that was probably synchronous with the Würm glacial epoch in Europe.

The human skeleton, as has been said, came from the next to the lowest horizon (No. 2). It is not only in a good state of preservation, but is likewise practically complete. The skeleton was found some three or four meters below the rim of the Oldoway gorge, which here is about fifty meters deep. The skeleton bore the same relation to the stratified bed as did the other mammalian remains and was dug out of the hard clay tuff with hammer and chisel just as these were. In other words, the conditions of the find were such as to exclude the possibility of an interment. The human bones are therefore as old as the deposit (No. 2).

An attempt to determine the age of the human skeleton with any degree of accuracy must, of course, wait upon a further study of the geologic and paleontologic data, as well as on a more thorough-going somatologic study of the skeleton itself. Dr. Reck is, however, already convinced that it antedates the so-called alluvial or recent period. The thickness of the deposits indicates a considerable lapse of time, especially when one recalls that at least two of the superposed deposits were laid down before the faulting occurred, and with it the drying up of the lake. The change in fauna from rhinoceros, hippopotamus and two types of elephant both different from the living African elephant, to a gazelle and antelope fauna is likewise proof of considerable antiquity. Judging from the photograph of the skeleton still *in situ*, the man of Oldoway gorge did not belong to the Neandertal, but rather to the Aurignacian type of man. In the absence, however, of industrial remains and even photographs in detail, any pronouncement as to racial affinities with known European Quaternary human remains would be merely a guess.—*Science.*

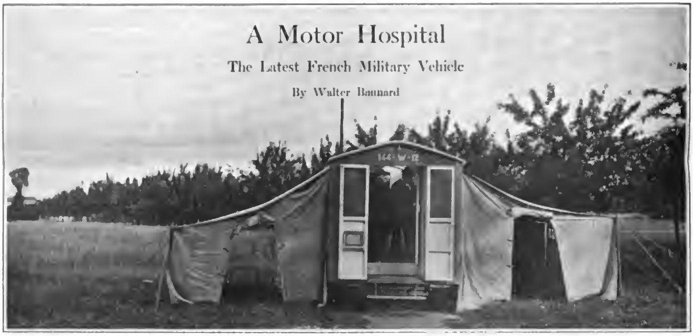
Activity of Freshly Formed Radium Emanation

H. H. Poole, in the *Phil. Mag.*, says that as there is no very satisfactory explanation of the exponential law of radio-active decay, it is not unreasonable to suppose that variations from it might occur under certain conditions. For instance, as has been suggested by Joly, it is possible that the rate of decay, and hence the activity of a body, might be anomalous when the body is freshly formed, so that its age is only a very small fraction of its average life. Accordingly, the author has compared the activity of RaEm a few seconds old with that of the same emanation at the age of a few minutes. The results were negative, nothing anomalous being detected.

A Motor Hospital

The Latest French Military Vehicle

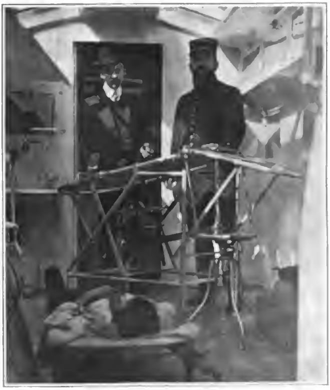
By Walter Baunard



THE French army has an automobile operating room, in which surgical operations can be performed at the battle-front in conditions as favorable as those afforded by a hospital. Severe abdominal wounds, which are very common in modern warfare, cannot be operated upon properly by the ordinary field service, and in many cases the removal of the patient is equivalent to a sentence of death.

The new vehicle, which has a 40 horse-power motor, capable of developing an average speed of 20 miles per hour, is furnished with all of the accessories and the latest improvements of a hospital operating room. Its principal compartment, the operating room proper, contains an improved operating table and a wash basin supplied with sterilized water. In front is a smaller compartment, containing the sterilizing apparatus and the electrical apparatus, which is operated by the motor, whether the vehicle is in motion or at rest.

A very ingenious arrangement enables the surgeon to locate the bullet accurately by the application of Roentgen rays. The operator, shielded from diffuse light by a photographer's hood, moves the fluorescent screen over the patient's body until the shadow of the bullet falls on a small hole at the center of the screen. By inserting a pencil in this hole, the position of the shadow is marked on a sheet of translucent paper, ruled in squares, which is placed under the screen. The angle of observation is then altered slightly and the new position of the projection of the bullet is marked in the same way on the ruled paper. From the distance between the two marks, the depth of the bullet can be obtained, by referring to a table computed in advance.



The operating room of the motor hospital contains operating table, trepanning apparatus, and sterilizing basin.

The operating room also contains a complete trepanning apparatus, which is operated by a special motor.

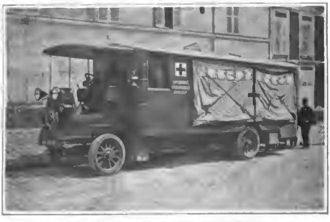
The vehicle carries an apparatus for sterilizing water by ultra-violet rays, for the use of the troops. The water is drawn from any convenient brook or pond by an electric pump.

A folding tent, for the shelter of patients before and after operation, is attached to each side of the vehicle.

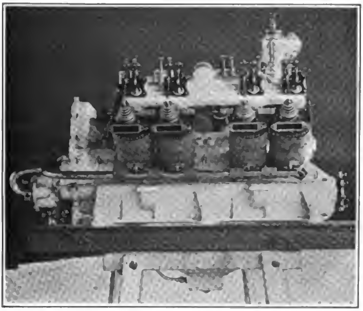
The employment of automobile operating rooms of this sort will save many lives. In the recent war in Manchuria the mortality among the severely wounded was 90 per cent, because of the inadequate facilities for prompt operatory treatment. This mortality can probably be diminished by two thirds by the use of automobile operating rooms in which operations can be performed in perfectly aseptic conditions, without loss of time, before the removal of the patient from the field.

A Number of Folding Go-cart Patents.—We are all more or less familiar with the general appearance of the folding go-carts or perambulators made partly out of what appears to be oil cloth. Patents Nos. 1,094,417 to 1,094,419 on applications of Frank J. Beier and Nos. 1,094,453 to 1,094,460, inclusive, on the applications of Albert E. McGill, have been granted, showing various constructions of go-carts of this class. All of these patents except 1,094,457 have been issued to William S. Ferris, Elkhart, Ind., and Alexander B. Heath of Chicago, Ill., trustees, as assignees.

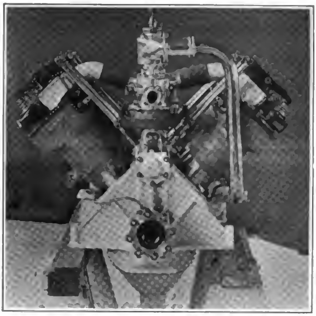
Showing the method of suspending stretchers in a military hospital vehicle, and the positions of the patients.



The motor hospital, besides its operating and sterilizing equipment, carries a shelter tent on each side, ready for pitching.



Side view of V type, water-cooled motor.



End view of V type motor, now favored for high powers.

Late Types of Aero Engines

With the natural advance in the art of aerial flight larger airships and planes of various kinds are constantly being designed, and for their operation there is a steadily increasing demand for more power; and indeed these demands for increased power have become so insistent that the designers and builders of engines of this class are finding it extremely difficult to keep up with them because of the limitations of weight and restrictions as to size. As a matter of fact the newer and larger of the flyers appear to depend more on increased power for their success than on any radical improvement in their conception; and while the restrictions imposed on the designers of the engines are within reasonable limits, a stimulus to improvement, the limitations to weight still insisted upon is producing an engine, which while remarkable for its mechanical perfection and efficiency, cannot be regarded in any sense as reliable, nor of a character that would be accepted for anything except purely experimental work.

Up to about one hundred horse-power the rotary type of motor gave very good results and was very favorably regarded, but where greater powers are required, and longer flights are contemplated, engines more nearly approaching automobile lines are preferred as they have proved themselves more dependable and durable, and many of the more recent flights that have been notable for either duration or distance have been made with the assistance of water-cooled motors of the above type.

Many of these new engines of high power that have been installed in foreign countries of late have been produced by well-known automobile builders, who have also had considerable experience with fast motorboats, and the aero engines they build may be considered a condensation of their experience with light, high-speed motors. One of the most recent designs is by the Wolseley Company, the well-known British builders, and as it is fairly typical of its class the accompanying illustrations and details are given.

This engine is a four-cycle of the "V" type having eight cylinders 5 by 7 bore and stroke set at an angle of 90 degrees on a cast aluminium crankcase. These cylinders are of high carbon steel, machined out of the solid and fitted with copper water-jackets. The pistons are of the same construction as the cylinders, and are fitted with four rings each, two of which are compression rings, while the other two merely serve as guides or bearings. The valves are placed in the cylinder head, and operated by overhead rocking levers and rods from an inclosed central camshaft that serves both sets of cylinders, and is driven from the crankshaft by gears. The valves are all set in removable seats, and the exhaust valves work in detachable water-cooled boxes. A forced system of lubrication is employed, one gear pump feeding oil under pressure to all important bearings, and a second pump returning the oil from the crankchamber base to the tank, the consumption being approximately 0.05 pint per brake horse-power hour. A gear pump working in conjunction with a radiator takes care of the cooling, while the ignition is the dual system, consisting of a high-tension magneto and coil, with starting switch and accumulator.

This engine weighs about 950 pounds, while the water in jackets and radiator amounts to 120 pounds. At 1,250 revolutions per minute 130 horse-power is developed with a consumption of approximately 0.65 pint of gasoline per brake horse-power hour. Any suitable carbureter may be used, and it can be placed as shown in the cuts, or located lower down at the end of the engine; while the gasoline can be fed by pressure if desired.

Wireless Communication and Aeronautics*

Facts Relating to Light Portable Apparatus

For wireless installations on board aeroplanes and balloons the most important consideration has been to install apparatus which will conform to the limitations of weight and space, and still provide a suitable and efficient means of transmitting messages to the desired points with the small aerial wire system and power of aircraft. The demand for light and portable stations for army and navy work is constantly increasing. In time of war, wireless communication is of great service in connection with aeronautics, for it enables the leaders to send commands rapidly and to learn the position of the enemy. The operator is usually carried as a passenger and transmits signals at the same time as he makes observations. The apparatus used is, in all respects, interchangeable with the portable field sets, as this enables any operator of the field signal corps to work the aeroplane outfit when necessary. It is so arranged that the machines are of the double key type, so that messages can be sent by either the aviator or the passenger.

The current is obtained from a generator, friction-driven from the fly-wheel of the engine or from storage cells. Experiments have also been made with wind motors where the generator was driven by an aeroplane.

The equipment at present used by this government has an output of about 125 watts, weighs about 75 pounds, and, it is claimed, has a radius of 30 miles. A new equipment designed by the author has a total weight of less than 20 pounds with double the capacity and less than one half the space required by other outfits.

Recently several European Governments have been making experiments with apparatus for army work and have arranged conditions different from those which have been planned and adopted by all wireless workers up to date, in fact, have gone back to the old days when the ordinary Hertz oscillator, untuned and of open circuit, was used. Now several officials are suggesting the use of apparatus wherein the transmitter is not tuned, and they advance several points in its favor.

The Dubilier Wireless Apparatus.

First, in transmitting a sharply tuned signal it takes a longer time for the receptor to get into proper adjustment for receiving signals.

Secondly, the transmitter can be more quickly adjusted, as it is not necessary to adjust the oscillating circuits carefully in order to bring them in resonance.

Thirdly, messages can be sent in secret code. Hence it does not matter whether the enemy receives them or not. If the signals sent out are not tuned sharply, the greatest hindrance can be offered to the enemy by interfering with his stations; for it will be difficult for him to tune out these highly damped waves. It has therefore been desirable to send out waves with a flat resonance curve.

In order to get the largest amount of power out of the transmitting station and to arrange the circuits in resonance, the following figures will be of great interest to give one an idea of the size of the aerial and capacities required in installations:

The speed of electric waves is about one billion feet per second. If oscillations or waves of a frequency of one million is desired, it will be necessary to have a wave length of about one thousand feet; for to send messages with wave length of very much less is not practical, because of many difficulties such as absorption, heat losses, induction losses, etc. Therefore, if signals are to be sent, longer wave length should be obtained by using large inductances. The size of these is also limited; for the machine again becomes inefficient when too much inductance and too little aerial capacity is used. Hence, a compromise must be made whereby sufficient aerial length and surface are coupled with a fairly large inductance. To get an idea of the length of the aerial roughly, the wave length transmitted is 5 times the length of the aerial wire system plus 10 times the length of wire in the coil or helix. To make up the length, usually a trailing wire is used which is led down from the aeroplane or balloon, or an auxiliary balloon is used for elevating wires. This plays a very important part in determining the range of a wireless station, for roughly it varies directly with the height of an aerial and cube root of the power.

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* Abstract from a paper by William Dubilier read before the Aeronautical Society of America, June 11th, where he prefaced his remarks with a note on the history of wireless and its adaptation to Aeronautics.

Many different kinds of apparatus have been designed for aeroplane work. Portable stations supplied by the Marconi Company, type L, especially adapted for aeroplanes, weigh 50 pounds and have a capacity of 50 watts and a radius of about 10 miles. Type L1 weighs 200 pounds, has a capacity of about 500 watts, and a sending radius of 50 miles, while type M, for durable work, has a capacity of 1,500 watts, a sending radius from balloons of 200 miles and weighs 500 pounds. One of these installations, tried on board the "Flanders," British machine, and made up in two separate contained units with the idea of distributing the weight, was fitted underneath the pilot and passenger seat, and the only part exposed was the manipulating key with several controller switches which were placed in the most convenient position for the operator to carry out the simultaneous work of observing and reporting.

Another aeroplane installation used is one constructed by the Lorenz Company, using a quenched discharge gap for the production of nearly continuous oscillations. The weight of the transmitter without the generator is 100 pounds, the dynamo used is 500 volts, with a capacity of 500 watts. This apparatus consists of a discharge gap of two large electrodes, each electrode shaped like a half ball and cooled by a hydrocarbon vapor. Although this apparatus is not efficient, it has already been installed by several of the foreign governments.

The Telefunken Company have also made an apparatus for aeroplane work which has a capacity of about 300 watts, and occupies three cubic feet. A small dynamo is used, belt or friction driven from the main engine, and this apparatus has a sending radius of from fifteen to twenty miles.

For balloon installations, where large aerials can be constructed, much greater distances could be obtained. It has been reported that the Zeppelin airships are transmitting signals 200 miles with a 5 kilowatt installation, and all the Zeppelin airships that are making public trips have on board regular telegraph forms, the same as used on ship stations, so that passengers can send their messages at published rates to any part of the world. The aerial on board a Zeppelin dirigible is almost 600 feet long, and a 500-cycle generator is driven by an independent engine at a speed of 3,000 revolutions per minute. The wave length varies from 400 to 1,200 meters.

The greatest danger attached to balloons from wireless installations is the fact that the gas may become ignited by sparks produced by induced currents. This danger cannot be eliminated with the larger installations where high voltage transformers are used, but there are certain systems, such as the Poulsen, Lorenz and the author's, where the voltage of the transmitting oscillations is greatly reduced, thus eliminating to some extent the danger of induced currents. All metal parts such as valves, etc., must be thoroughly covered with a thick coating of some form of insulating varnish. For balloon work the wireless telephone is the most practical method for transmitting communications, for it eliminates the telegraph operator and the dangers of an explosion by brush discharge, and makes possible quick transmission of signals.

The portable Dubilier apparatus weighs 20 pounds, with a maximum capacity of one half kilowatt. The system eliminates the use of the difficult high frequency alternator. A small direct current dynamo is used, and then by a simple device alternating currents are produced having any desired frequency from 200 to 800 cycles, thus sending signals with musical notes. The apparatus is much easier and cheaper to construct than any yet provided for portable work; it is much smaller and much more compact for given power and is more portable and readily adapted for transport purposes; it is especially designed for aeroplane installations, where power, space and weight are important considerations.

From tests made by both the British and United States governments, the apparatus has proven itself more than twice as efficient as any of the machines yet tried. In a report issued by Capt. LeFroy, it is stated that with a 60-watt, 110-volt set, signals were sent from standard portable aerial and received on a service pack aerial 30 feet high consisting of 2 wires in parallel, 4 feet apart. A ground net with a peg driven 12 inches into the earth was used as a balance capacity. The station was erected on grass, and 104 volts direct current were used for transmitting. The current in the aerial was 1½ amperes. The condenser capacity was 0.0015 microfarads, a loose coupler being used. The maximum voltage across the spark gap was 7,000, which was of the quenched type adjusted to give the best readings in the aerial. Tests were made with three ranges in connection with a 300-watt Marconi installation set up alongside for comparisons. From Aldershot a motor car with a portable installation went out to three distances, first to Hook Common, 9 miles; second to Overton, 20 miles; third to Whitchurch, 25 miles. In the first two places signals were received clear, indeed with eight times the audibility at the latter test. At the third test the receiving end was connected to the wrong side of the aerial which was direct and which was in a valley so that no signals were obtained. Capt. LeFroy reported that this apparatus which weighed but 15 pounds, less the generator, had a safe range of 20 miles over land. The same apparatus operated on a 50-volt accumulator weighing 35 pounds had a clear radius of approximately the same distance.

Roughly the principle used is the producing of pulsating currents of a musical frequency from direct currents by means of a tuned circuit. This circuit contains a condenser charging device, a condenser and an inductance. The condenser charging device is set in operation mechanically or electromechanically, and, by means of springs, is given a certain definite working frequency, say 500 cycles. Then the inductance and capacity are so varied that the natural frequency is also 500 or a harmonic of the frequency of the oscillator. The primary current is transformed into pulsating currents having a sine wave with over 95 per cent efficiency. A suitable analogy can be shown by having constant water flowing out of a faucet which will represent direct current and then having another faucet with water running out into a cup or into a vessel which operates a lever by means of its weight when it becomes filled. This lever closes a valve and at the same time drops and turns over the vessel which releases the water. The release of the water operates the lever in the opposite direction, due to its lighter weight, and the vessel is then brought up again in position. The valve is simultaneously opened and the water again allowed to flow into the vessel until it is filled and then the operation is repeated. We have quantities of water thrown out instead of a continuous flow. Similarly this system operates on direct current.

The inductance of the primary oscillating circuit acts as the primary of a high tension transformer, the secondary discharge of which produces oscillations in the well-known manner. A quenched spark is used of a special design and is mounted inside the cover of the apparatus. This gap consists of long copper bars with smoothly planed ends placed about 0.003 of an inch apart, the discharge taking place between the planed ends. Any number can be connected by a small short-circuiting rod. The inductance is mounted in back of the instrument, and is connected to a hot wire ammeter which indicates the amount of power that is being radiated.

In experiments carried out by Messrs. E. J. Simon and L. J. Lesh, an aerofan was used to drive the generator. This was equipped on board a Curtiss military hydroaeroplane and was of about ½ kilowatt capacity with a 500-cycle generator driven by a fan 20 inches in diameter. An aerial wire 600 feet long was wound on a reel, and weighted by a three pound piece of lead. This was used as the trailer and taken in as it became necessary. The installation weighed 105 pounds. It was found necessary to attain a fairly good speed to generate enough power to operate the apparatus efficiently.

The question of receiving signals on board aeroplanes and balloons has been a very difficult one, for the noise and vibrations of the engines and air currents make it impractical to receive signals with a telephone receiver. A receiving apparatus was designed for the Austrian Government in which a visible signal was used. The operator is able to observe dots and dashes by means of a small light. It is advisable to use Prof. Fleming's oscillation valve, or Dr. De Forest's audion, for they act as amplifiers to the received signals and are not affected by vibrations.

European Field Artillery[*]

A Discussion of Belgian, German, and French Guns

The determined defense of the Belgians at Liege was made doubly necessary by reason of the important artillery and small-arms works located there. The Belgian government is almost wholly dependent on the Liege district for arms and armament.

IMPORTANT LIEGE INDUSTRIES.

The great Cockerill Works (Societe John Cockerill) is located close to Liege at the suburban town of Seraing. Ordinarily the Cockerill Works gives employment to more than 10,000 men. The principal output consists of artillery and coast defense material. Belgium for a number of years past has added armored cupola defenses to her land fortifications, and the majority of these cupolas were built by Cockerill. The standard Belgian field-artillery gun is of Cockerill design and is known as the Cockerill gun. The caliber is 2.95 inches. In addition to field pieces Cockerill turns out large caliber guns for coast defense positions. The output at the Cockerill Works also includes locomotives, steam and gas engines, and a varied lot of railroad equipment. The plant is easily the most important in size and output in Belgium. Much of the machine-tool installation is not as modern as can be found in other Belgian plants, but of late years Cockerill has undertaken to introduce many American machine tools, and especially those of the automatic type, together with grinders and milling machines.

The Fabrique Nationale d'Armes de Guerre is located at Herstal, a suburb of Liege, and gives employment to over 3,000 people. The rifles, carbines, and revolvers used in the Belgian army emanate for the most part from the Liege district. In and about Liege are some thirty-five firms engaged in the production of sporting arms, the largest being probably the Pieper Works. This establishment has installed the latest types of machine tools obtainable and the equipment is largely American. The Pieper plant undertakes to do all work within its shop limits. Other shops arrange to have work taken to the homes of the workmen, under the idea that overhead charges are cut down. At such plants only assembling work is carried on.

Liege boasts of two important machine-tool works, namely, De Longdoz and Fetue-Defize. Still another plant, Jaspers, but smaller, is located there, and midway between Liege and Seraing is Beq de Maizine, one of the best fitted up gear-cutting plants in all Europe. Ninety per cent of the machine tools at Maizine are of American origin. The same statement may almost apply to the Melotte Works, located a short distance to the north of Liege. At the last named plant almost the entire installation of tools came from the United States. The great machinery works known as the Meuse Works lies just outside the city of Liege, while within the confines of the town proper is the St. Leonard Locomotive Works, one of the oldest and best known in Europe.

Liege is indeed a great machinery section, and the closing of all the above plants may naturally be expected in consequence of the war—all but the gun plants, since the latter can be utilized so long as they can be held.

BELGIAN AND FRENCH FIELD ARTILLERY.

The greatest importance is ascribed by military men to the part which field artillery will play in the present struggle. In 1870 France was clearly outclassed by Krupp wedge-block field guns. The French pinned great hopes on the mitrailleuse, a form of machine gun, but that weapon failed miserably at the very outset of the war. Private firms in Europe like Krupp, Skoda, Schneider & Co., and Cockerill have carried forward the development of field artillery year by year. Some idea of the advances made was first gleaned by the work of French guns in the Boer war. These pieces easily out-ranged the English standard field-pieces. The French guns in the hands of the Boers were Schneider pieces manufactured at Creusot, France. In the late Balkan war the Servians did remarkable work with still later makes of Schneider guns.

There is a popular impression that the French army is equipped with field guns of the type made familiar by the Servians and the Boers. This is erroneous. The French government gun is manufactured at the government arsenals and under no circumstances can it be purchased. The greatest secrecy surrounds the manufacture of this weapon, and it is the rule to keep the guns well covered with tarpaulins when on parade. French ordnance officers superintend all steps of the manufacture of these pieces, and there is no letting out or contracting on the part of private plants.

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[*] *The Iron Age.*

The field guns in use throughout the European services to-day all employ the long recoil system; that is to say, the gun carriage is immovable. In the case of guns not so equipped there is necessary a running of the gun into battery again after each discharge. The long recoil guns have the recoil taken up in cylinders either placed under the carriage or along the trail. The mechanical arrangement differs in different services, but the principle is the same, namely, to hold the gun carriage rigidly in place, and to allow the gun to recoil on the carriage, without moving the carriage. The energy of recoil is utilized to run the gun out after each discharge to its normal position on the carriage.

The effective development of the long recoil field carriage only began after 1897, when France had adopted her model of that year. When long recoil was first attempted, hydraulic transmission was tried, but the complications proved to be too great, and recourse was had to spiral springs. These springs were applied in the recoil cylinder in layers, with telescopic tubes. Ehrhardt, a German artillery manufacturer, tried to do without the tubes by winding the springs in the opposite direction, but this system has not been followed to any great extent. England purchased Ehrhardt guns during the Boer war, as her own pieces were recognized as having been outclassed.

In the late Krupp guns the action of the recoil is transmitted directly on a single spring without any of the complications arising through affording transmission between recoil and counter recoil. The brake piston rod of the Krupp field gun is held in the head of the cradle by a nut, and the brake cylinder is fixed to a lug at the breech of the gun. The spiral spring of flattened wire surrounding the cylinder is retained by the bottom of the cradle in the rear and compressed by a collar on the brake cylinder in front. The recoiling gun, pulling the cylinder back through the rear plate of the cradle, compresses the spring. There is no transmission, and recoil and compression are of equal length.

SHRAPNEL FIRE.

The object to be attained by modern field artillery is effective shrapnel fire. The majority of the European field pieces have a caliber of 2.95 inches and throw a shrapnel projectile weighing about 14½ pounds. This shrapnel shell is fitted with about 200 bullets, and experience shows that those bullets, to do effective work against men and horses, must have a striking energy of about 700 foot-pounds. The walls of the shrapnel shells are thin. Only a small bursting charge is necessary to tear open the walls and release the bullets. The bullets do not gain an increased impetus or velocity in consequence of this bursting of the shell; on the contrary, the velocity of the bullets following the burst is the velocity of the shell proper.

Shrapnel is burst over and short of the object fired at, and is designed especially for use against troops in the open or sheltered behind light screens. By being burst over earthworks, the bullets will search out the troops sheltered behind. The Boers found the English shrapnel so searching that they had recourse to digging their trenches at a slope, the bottom of the trench sloping toward the enemy.

The question as to the range of shrapnel depends on the initial velocity of the projectile. There is a maximum velocity dependent upon the firing charges of the gun itself. It is understood, however, that the new French guns have an effective shrapnel range of 6,000 yards. It was not many years ago when 3,500 yards was considered a good shrapnel range.

The effective use of shrapnel as in evidence to-day was unknown in the United States during the civil war. Solid shot and shells carrying lighted fuses were used for long-range work, and grape and canister for close work. The cannoneers stood up in the open. The caissons stood about fifteen to twenty yards in the rear, and men ran with the charges between the caissons and the guns.

MODERN PROTECTION TO GUNNERS.

All this is changed to-day. Instead of the caissons being in the rear, the French and Belgians place the gun caissons alongside the guns, and not more than two to three feet away. The guns are provided with shields, and after the first shot the gun is rigidly planted in the ground. Two men operate the piece, one to train and fire, and a second to load and eject the empty cartridge case.

The gun caisson or limber is up-ended much like a dump cart, only the ending of the caisson body is made complete; that is to say, it stands almost perpendicular to the ground and not at a slant. The projectiles when carried on the march have their heads down, but with the running of the caisson into battery and up-ending the cartridges lie parallel to the ground. The top of the caisson consists of two doors, which swing outward when the caisson is up-ended and form wind protection for the gunners who serve out the ammunition.

The bottom of the caisson and the wing doors are of light steel construction, not over ¼ inch in thickness, and are impervious to steel-jacketed bullets of the standard military rifle.

Three gunners kneel behind the protecting bottom of the caisson. They are completely sheltered from rifle fire. Two of these men pass out the ammunition; the third cuts the shrapnel fuse to the required number of seconds. As a rule the time of flight does not extend beyond 22 seconds, and for ordinary shrapnel service 10 to 12 seconds are employed. It all depends on the distance of the enemy. Good practice demands that the shrapnel be burst at a point about 150 yards short of the object fired at. The effect is to release the small balls within. The bullets then rush on at the full remaining velocity of the shell in the form of a sheaf, and strike the ground within a rectangle about the size of an ordinary company formation. The dispersion of the bullets is regulated largely by the position of the bursting-powder charge. In the case of some makes of shrapnel, the bursting charge is in the head of the projectile, while in other designs the charge is at the base of the shell. Shrapnel shells are in a number of services provided with percussion fuses in addition to the time mechanism. This insures the bursting of the shell when striking the ground.

RAPIDITY OF GUN SERVICE.

In the Belgian and French plan of placing the caissons when in action alongside of the guns there is gained great rapidity of service, and a rate of fourteen to fifteen aimed shots per minute is readily obtainable. An even higher rate of fire can be conducted, but fourteen aimed shots are perfectly practicable under varying conditions. By keeping the caisson close up to the guns there is avoided any exposure of men in running with ammunition to the guns. Opponents of the practice point out that if the caisson is exploded by a shot from the enemy it will probably also destroy the gun, but there is no knowledge, so far as known from experience, that the same thing would not happen if the caisson were exploded fifteen yards in the rear of the piece. The target presented by caisson and gun on the same front line is regarded as hardly more dangerous than a deep target afforded by placing the caisson fifteen yards to the rear. Incidentally, it may be remarked that the latter practice has been followed in the United States service, but many artillery officers believe that the Belgian and French method is preferable. In the French and Belgian practice the horses are moved off to the rear two hundred or three hundred yards, if necessary, wherever protection can be found in some hollow of the ground. Both the Belgians and French resort to indirect fire; that is to say, guns are sheltered behind a knoll or ridge, or, if necessary, sunk in pits, and the fire is directed by the battery commander from wherever he can best see. It is not necessary that the gunners have more than the range, time of flight, and direction of fire. The battery commander watches the burst of the shrapnel. If it is too short, he forks the object fired at by an increased range, and then reaches the object on the third shot by taking a mean of the two ranges. Seldom more than two trial shots are required.

The Krupp guns train through 8 degrees of arc without any necessity for shifting the carriage. French guns have greatly increased this train by having recourse to two additional trail flasks which are spread out V-fashion in rear of the gun.

FRENCH LONG RANGE GUNS.

It was Gen. Langlois of the French army who is regarded as the father of the present-day French army field-practice. This officer for several years urged upon the French government the developing of a gun which should be superior in range and rapidity of fire to any field gun in the world. His arguments and claims that the thing could be done finally resulted in the War Ministry taking the matter up in earnest. Langlois, as a practical artillerist, indicated what was required, and what should be striven for, and Col. Dupont, a renowned ordnance engineer, was assigned to work in conjunction with him. These two officers have evolved the field-piece which France now possesses and on which France depends for her armies to win in the field. The great Puteaux arsenal is responsible for many of these guns, and it may interest American machine-tool builders to know that American arsenal tools constitute the bulk of the equipment utilized in the fabrication of these pieces.

Lord Roberts is quoted as saying that the Boer war taught the necessity of having long-range guns with armies in the field. This necessity was felt when opposed to the Schneider guns of the Boers, the lighter guns having been outclassed. It will be recalled that the English sent to the front 4.7-inch and 6-inch naval guns taken from British cruisers and improvised carriages for the use of those guns on land. It is doubtful if any such disparity will arise between field guns in the various European services, but it is apparent that Krupp 75-millimeter (2.95-inch) field guns are unequal to attacking armored cupolas such as are found in the defenses of Liege. Against such defenses heavy pieces are needed, and then recourse must be had to specially built armored flat cars running on railroad tracks and of sufficient strength to withstand the heavy shock recoils. Such carriages, it is understood, exist, but the difficulty is to transport these armored trucks to the front, especially when railroads have been torn up, bridges destroyed, and roads damaged so as to prevent any rapid reconstruction. Against armored cupolas of the Belgian Cockerill type 8-inch guns, it is estimated, alone will suffice, and these 8-inch guns approximate fifteen and twenty tons in weight.

The Problem of Relativity[*]

There are two theories of relativity which should be clearly distinguished from each other. One, which may be called the theory of relativity in the strict sense, is supported by many observed facts, and is regarded by most physicists as the simplest theoretical expression of those facts. The other theory, which may be called the theory of relativity in the wider sense, has little, if any, experimental foundation, and is regarded with skepticism by the great majority of physicists.

I. THE THEORY OF RELATIVITY IN THE STRICT SENSE.

Newton's laws of motion do not hold for a system of co-ordinates moving in any manner whatever. But, if the motion is referred to a system for which these laws are true, they will be equally true for any other system whose movement, relatively to the first system, is a movement of pure translation with uniform velocity.

The validity of this principle of relativity cannot be doubted if we believe that all phenomena can be explained by the laws of mechanics. Even without this assumption it is evident that, if the principle of relativity in the strict sense were not true, certain phenomena which are referred to a system fixed relatively to the earth might be affected by the earth's rotation or its revolution around the sun. Not the slightest effect of this character, however, has been detected by the most delicate measurements, such as those of Michelson.

The principle of relativity in the strict sense, therefore, has stood the test of experiment. If it long seemed doubtful, and is still so regarded by some physicists, this is because it appears irreconcilable with the electrodynamical theories of Maxwell and Lorentz. In particular, the constancy of the velocity of light, which is deduced from those theories, seems difficult to admit.

If, for example, the ray of light and the observer are moving in the same direction with velocities V and v, it would seem that the velocity of the light, estimated from the observer's point of view, should be V-v.

An exact analysis of the physical meaning of our data of space and time proves that this contradiction is only apparent. "It rests," says Einstein, "on the two following arbitrary hypotheses; first, that the statement that two events occurring in different places occur simultaneously has a meaning independent of the system of reference; second, that the distance between the places in which two events occur simultaneously is independent of the system of reference."

If these arbitrary hypotheses are renounced, the constancy of the velocity of light becomes compatible with the principle of relativity. We may assume that a ray of light moves, *in vacuo*, with the same velocity relatively to any two systems of co-ordinates whose relative movement is one of uniform translation. We need only make a proper choice of the equations of transformation that connect the co-ordinates of space and time (x, y, z, t) of one system with the co-ordinates (x', y', z', t') of the other. These equations of transformation, called "Lorentz's equations," should replace the ordinary equations of transformation, which were used before the theory of relativity was developed, and which are based upon the arbitrary hypotheses mentioned above.

Thus the theory of relativity furnishes a condition which must be satisfied by all systems of equations that express general laws of nature. It does not furnish means of evolving natural laws hitherto unknown, but it gives a criterion of universal applicability which limits the possibilities. In this respect it resembles the principle of equivalence, Carnot's principle, and Curie's principle of symmetry.

Now there is one domain of fundamental importance in which our empirical knowledge is far too small to supply, even in conjunction with the principle of relativity, a firm basis for a general theory, so that the foundation must be completed by physical hypotheses. This domain is gravitation. It is sometimes said that the theory of relativity fails when it is applied to the explanation of gravitation, but the failure appears to be due to the dearth of experimental data. Einstein thinks, however, that the theory recently enunciated by

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[*] Translated from A. Boutaric's *résumé*, in *La Revue Générale des Sciences* of Einstein's article in *Scientia*, May, 1914.

Nordstrom, which satisfies the principle of relativity, is an interesting tentative solution. In this theory the *weight* (regarded as a coefficient determining the force experienced by a body in a field of gravitation) of an isolated system, integrally at rest, is in general a fluctuating quantity, the mean value of which at any instant is given by the total energy of the system. Such a system would continually emit longitudinal waves of gravitation, but the loss of energy thus caused would be far too small to be perceptible.

II. THE THEORY OF RELATIVITY IN THE WIDER SENSE.

Orthodox mechanics and the theory of relativity in the strict sense do not suffice, in Einstein's opinion, to give a physical image of the universe that satisfies a mind open to philosophical arguments. For example: "We try in vain to explain what we mean by the acceleration of a body. We are able to define only relative acceleration, the acceleration of one body with respect to another. But, on the other hand, we found our mechanics on the hypothesis that a force (cause) is required to give a body an acceleration, forgetting that we cannot indicate what we mean by acceleration, because relative accelerations are the only ones that can be perceived."

Einstein, therefore, proposes to generalize the theory of relativity in a manner that will obviate the foregoing objection.

"In the first place, I admit that an absolutely fundamental part, in such a theory, must be assigned to universal gravitation. For, from the preceding remarks it follows that every physical process, because it involves quantities of energy, necessarily creates a field of gravitation. On the other hand, the observed fact that all bodies fall in the same manner in a field of gravitation suggests the idea that physical processes are accomplished in a field of gravitation as they would be accomplished relatively to an accelerated system of co-ordinates (the hypothesis of equivalence). Starting from this conception, I reach the conclusion that the velocity of light should not be regarded as independent of the gravitation potential. The principle of the constancy of the velocity of light, therefore, is incompatible with the hypothesis of equivalence, and, consequently, with the theory of relativity in the strict sense. Thus I was led to regard the theory of relativity in the strict sense as applicable only to regions in which there are no perceptible differences of gravitation potential. The theory of relativity in the strict sense should be replaced by a more general theory which includes it as a limiting case." It is difficult to give even a vague idea of this generalized theory of relativity, which necessitates the employment of the most recent advances in mathematical analysis. The theory enables us to replace the known equations of physics by other equations which are valid for all co-ordinates of space and time. These new equations contain quantities which Einstein denotes by the symbol $\zeta_{\mu\eta}$ and which represents the field of gravitation. This field affects all physical phenomena and is itself determined by physical processes. Hence, every physical process is regulated by the quantities $\zeta_{\mu\nu}$, which, in turn, are determined by the physical processes of the entire universe.

This theory is free from the philosophical objections mentioned above. In partic ar, the equations of motion of heavy masses contain, not absolute accelerations, but accelerations relative to other bodies, which are the only ones that can be observed.

Steering Vessels by Electricity

In the proceedings of the American Institute of Electrical Engineers the subject of steering vessels by electrically operated gears was discussed by H. L. Hibbard, and a method for calculating the power required is given. The author gave a short account of the early designs, and a description of the recent equipment installed in American battleships. The following summing up of the features of steam and electrically driven gears covers the points discussed.

Among the disadvantages of modern steam steering gear the author mentions: (1) Long lengths of steam piping and lagging, and rises in temperature of spaces through which piping passes. (2) Wastage of steam, as steam steering gear takes full stroke, and the valve setting is often such that steam is always blowing through the engine. (3) The engine must be designed for the maximum work required of it, i. e., when rudder is at maximum angle. (4) Severe stresses on reciprocating parts due to sudden decrease of load when rudder goes back to central position. Mechanical connections from bridge to engine valve are a continual source of trouble.

Against these, the advantages of the electric drive are: (1) Reduction of weight and space occupied by driving mechanism. (2) Suppression of heat in compartments. (3) Elimination of accidents due to burst steam pipes. (4) Reduction of vibration and noise. (5) More efficient mechanism and the overload capacity of the motor can be used in extreme positions of the rudder. (6) Simplification of control from bridge. (7) Increase in rapidity and accuracy of response of the rudder to movements of the controlling mechanism.

Cable Conveyor System in Belgium

The well-known Cockerill metallurgical establishment of Seraing, Belgium, has in use a cable transporter of the Beer system which ranks among the most extensive of the kind in Europe. The transporter works over 7,000 feet in length, and has a difference of level of 500 feet between start and finish. As much as 150 to 160 tons of material per hour is carried, and the suspended cars take a standard load of 1 ton each. On its way the line passes over houses and streets of the town, and on almost all the course it uses wire netting underneath to protect against any falling material. When at the end of the traject, the cars are automatically overturned to discharge the load, then pass over the cable and back to the starting point of the line for reloading. At present the transporting system is running day and night and is said to handle upwards of 3,000 tons of material per twenty-four hours.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

A Beam Which Is Made Stronger if It Is Apparently Weakened

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

It sounds strange that a beam of triangular cross section, as shown in Fig. 1, is strengthened by being apparently weakened.

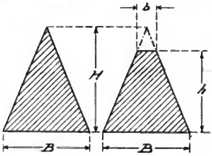

Fig. 1. Fig. 2.

The section modulus of a triangular cross section Fig. 1 is:

$$S = \frac{B \times H^2}{24}$$

if B represents the base, and H the altitude of the triangle.

If the apex of the triangle is cut off parallel to the base, as shown in Fig. 2, a trapezoid remains, the section modulus of which is:

$$S_1 = \frac{6b^2 + 6bb_1 + b_1^2}{12(3b + 2b_1)} \times h^2$$

in which b_1 represents B-b

To judge by the diagrams, one is inclined to think that the section modulus of the full triangular cross section is larger, but the contrary is the case; namely, if 13 per cent of the altitude of the triangle is cut away, the rest of the cross section has a larger section modulus, which exceeds the one of the triangular section about 10 per cent.

If $\frac{H-h}{H} = x$, hence

$$b = xB;\ b_1 = (1-x)B;\ h = (1-x)H.$$

These values inserted in the formula for S_1

$$S_1 = \frac{6x^2B^2 + 6x(1-x)B^2 + (1-x)^2B^2}{12(3xB + 2(1-x)B)} (1-x)^2H^2$$

$$\text{or } S_1 = \frac{BH^2}{24} \times 2 \times \frac{x^4 + 2x^3 - 6x^2 + 2x + 1}{x+2}$$

$$\text{or } S_1 = S \times K$$

in which S represents the section modulus of the full triangular cross section and

$$K = 2 \times \frac{x^4 + 2x^3 - 6x^2 + 2x + 1}{x+2}$$

New York. OTTO FRICKE.

Brazil and International Legal Time

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In the SCIENTIFIC AMERICAN SUPPLEMENT, No. 2005, of June of this year, I read, under the heading of "Legal Time in Various Countries," an article by Dr. M. Philippot, in which I noticed an important oversight, and this is in your having omitted to include Brazil in the list of nations which have adopted the new system of official hour.

For the sake of an information and so that you may be well posted, I take pleasure in advising you that, contrary to what is stated in this article, in June of last year the Congress approved the law of "legal hour" and, therefore, since the first of January, 1914, this law has gone in force for the ascertaining of the legal time, having the meridian of Greenwich as main basis.

In accordance therewith, Brazil was divided into four distinct sections, the first having as legal same as that of Greenwich less two hours, and the last section, the time is to be diminished five hours.

Therefore, since January, 1914, Brazil has adopted the official hour. This decision will no doubt facilitate in extent the commercial relations, for, as above mentioned, the whole of the Brazilian territory was divided into four sections.

Trusting this information will be of some value for your goodselves, I beg to remain,

Rio de Janeiro. CESAR RORELLO.

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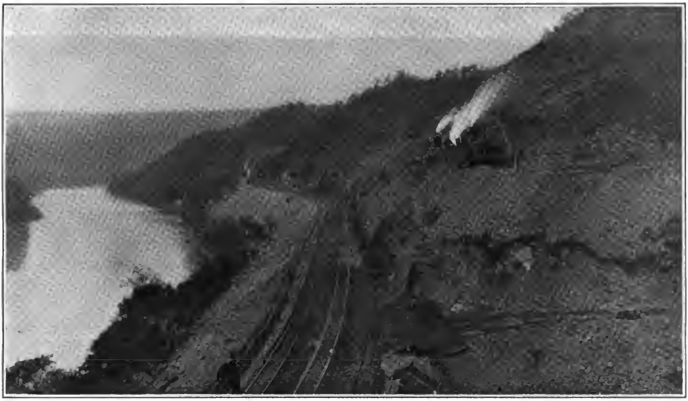
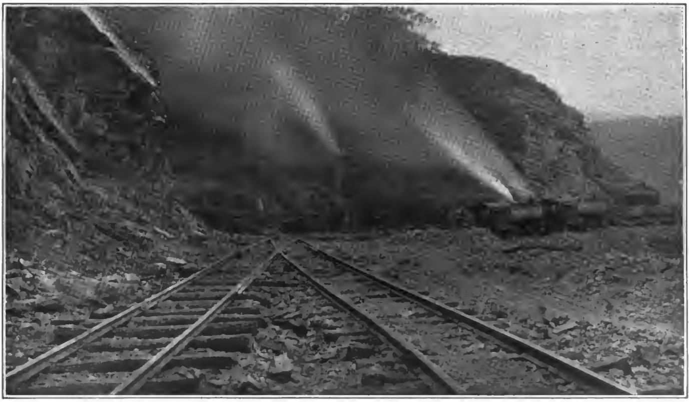


Forging the cut-off high above the level of the present roadbed. A point near Station No. 1592.



A bend in the line of the cut-off, westward from Station No. 1593.

THE MAGNOLIA CUT-OFF.—[See page 199.]

Heredity—III[*]

New Theories and Facts Relating to the History of Organic Beings

By Prof. William Bateson

Continued from Scientific American Supplement No. 2020, Page 179, September 19, 1914

I have mentioned the condition of certain animals and plants which are what we call "polymorphic." Their populations consist of individuals of many types, though they breed freely together with perfect fertility. In cases of this kind which have been sufficiently investigated it has been found that these distinctions—sometimes very great and affecting most diverse features of organization—are due to the presence or absence of elements, or factors as we call them, which are treated in heredity as separate entities. These factors and their combinations produce the characteristics which we perceive. No individual can acquire a particular characteristic unless the requisite factors entered into the composition of that individual at fertilization, being received either from the father or from the mother or from both, and consequently no individual can pass on to his offspring positive characters which he does not himself possess. Rules of this kind have already been traced in operation in the human species; and though I admit that an assumption of some magnitude is involved when we extend the application of the same system to human characteristics in general, yet the assumption is one which I believe we are fully justified in making. With little hesitation we can now declare that the potentialities and aptitudes, physical as well as mental, sex, colors, powers of work or invention, liability to diseases, possible duration of life, and the other features by which the members of a mixed population differ from each other, are determined from the moment of fertilization; and by all that we know of heredity in the forms of life with which we can experiment we are compelled to believe that these qualities are in the main distributed on a factorial system. By changes in the outward conditions of life the expression of some of these powers and features may be excited or restrained. For the development of some an external opportunity is needed, and if that be withheld the character is never seen, any more than if the body be starved can the full height be attained; but such influences are superficial and do not alter the genetic constitution.

The factors which the individual receives from his parents and no others are those which he can transmit to his offspring; and if a factor was received from one parent only, not more than half the offspring, on an average, will inherit it. What is it that has so long prevented mankind from discovering such simple facts? Primarily the circumstance that as man must have *two* parents it is not possible quite easily to detect the contributions of each. The individual body is a *double* structure, whereas the germ-cells are *single*. Two germ-cells unite to produce each individual body, and the ingredients they respectively contribute interact in ways that leave the ultimate product a medley in which it is difficult to identify the several ingredients. When, however, their effects are conspicuous the task is by no means impossible. In part also even physiologists have been blinded by the survival of ancient and obscurantist conceptions of the nature of man by which they were discouraged from the application of any rigorous analysis. Medical literature still abounds with traces of these archaisms, and, indeed, it is only quite recently that prominent horse-breeders have come to see that the dam matters as much as the sire. For them, though vast pecuniary considerations were involved, the old "homunculus" theory was good enough. We were amazed at the notions of genetic physiology which Prof. Baldwin Spencer encountered in his wonderful researches among the natives of Central Australia; but in truth, if we reflect that these problems have engaged the attention of civilized man for ages, the fact that he, with all his powers of recording and deduction, failed to discover any part of the mendelian system is almost as amazing. The popular notion that any parents can have any kind of children within the racial limits is contrary to all experience, yet we have gravely entertained such ideas. As I have said elsewhere, the truth might have been found out at any period in the world's history if only pedigrees had been drawn the right way up. If, instead of exhibiting the successive pairs of progenitors who have contributed to the making of an ultimate individual, some one had had the idea of setting out the posterity of a single ancestor who possessed a marked feature such as the Habsburg lip, and showing the transmission of this feature along some of the descending branches and the permanent loss of the feature in collaterals, the essential truth that heredity can be expressed in terms of presence and absence must have at once become apparent. For the descendant is not, as he appears in the conventional pedigree, a sort of pool into which each tributary ancestral stream has poured something, but rather a conglomerate of ingredient-characters taken from his progenitors in such a way that some ingredients are represented and others are omitted.

Let me not, however, give the impression that the unraveling of such descents is easy. Even with fairly full details, which in the case of man are very rarely to be had, many complications occur, often preventing us from obtaining more than a rough general indication of the system of descent. The nature of these complications we partly understand from our experience of animals and plants which are amenable to breeding under careful restrictions, and we know that they are mostly referable to various effects of interaction between factors by which the presence of some is masked.

Necessarily the clearest evidence of regularity in the inheritance of human characteristics has been obtained in regard to the descent of marked abnormalities of structure and congenital diseases. Of the descent of ordinary distinctions such as are met with in the normal healthy population we know little for certain. Hurst's evidence, that two parents both with light-colored eyes—in the strict sense, meaning that no pigment is present on the front of the iris—do not have dark-eyed children, still stands almost alone in this respect. With regard to the inheritance of other color-characteristics some advance has been made, but everything points to the inference that the genetics of color and many other features in man will prove exceptionally complex. There are, however, plenty of indications of system comparable with those which we trace in various animals and plants, and we are assured that to extend and clarify such evidence is only a matter of careful analysis. For the present, in asserting almost any general rules for human descent, we do right to make large reservations for possible exceptions. It is tantalizing to have to wait, but of the ultimate result there can be no doubt.

I spoke of complications. Two of these are worth illustrating here, for probably both of them play a great part in human genetics. It was discovered by Nilsson-Ehle, in the course of experiments with certain wheats, that several factors having the same power may co-exist in the same individual. These cumulative factors do not necessarily produce a cumulative effect, for any one of them may suffice to give the full result. Just as the pure-bred tall pea with its two factors for tallness is no taller than the cross-bred with a single factor, so these wheats with three pairs of factors for red color are no redder than the ordinary reds of the same family. Similar observations have been made by East and others. In some cases, as in the Primulas studied by Gregory, the effect is cumulative. These results have been used with plausibility by Davenport and the American workers to elucidate the curious case of the mulatto. If the descent of color in the cross between the negro and the white man followed the simplest rule, the offspring of two first-cross mulattos would be, on an average, one black: two mulattos: one white, but this is notoriously not so. Evidence of some segregation is fairly clear, and the deficiency of real whites may perhaps be accounted for on the hypothesis of cumulative factors, though by the nature of the case strict proof is not to be had. But at present I own to a preference for regarding such examples as instances of imperfect segregation. The series of germ-cells produced by the cross-bred consists of some with no black, some with full black, and others with intermediate quantities of black. No statistical tests of the condition of the gametes in such cases exist, and it is likely that by choosing suitable crosses all sorts of conditions may be found, ranging from the simplest case of total segregation, in which there are only two forms of gametes, up to those in which there are all intermediates in various proportions. This at least is what general experience of hybrid products leads me to anticipate. Segregation is somehow effected by the rhythms of cell-division, if such an expression may be permitted. In some cases the whole factor is so easily separated that it is swept out at once; in others it is so intermixed that gametes of all degrees of purity may result. That is admittedly a crude metaphor, but as yet we cannot substitute a better. Be all this as it may, there are many signs that in human heredity phenomena of this kind are common, whether they indicate a multiplicity of cumulative factors or imperfections in segregation. Such phenomena, however, in no way detract from the essential truths that segregation occurs, and that the organism cannot pass on a factor which it has not itself received.

In human heredity we have found some examples, and I believe that we shall find many more, in which the descent of factors is limited by sex. The classical instances are those of color-blindness and hemophilia. Both these conditions occur with much greater frequency in males than in females. Of color-blindness at least we know that the *sons* of the color-blind man do not inherit it (unless the mother is a transmitter) and do not transmit it to their children of either sex. Some, probably all, of the daughters of the color-blind father inherit the character, and though not themselves color-blind, they transmit it to some (probably, on an average, half) of their offspring of both sexes. For since these normal-sighted women have only received the color-blindness from one side of their parentage, only half their offspring, on an average, can inherit it. The sons who inherit the color-blindness will be color-blind, and the inheriting daughters become themselves again transmitters. Males with normal color-vision, whatever their own parentage, do not have color-blind descendants, unless they marry transmitting women. There are points still doubtful in the interpretation, but the critical fact is clear, that the germ-cells of the color-blind man are of two kinds: (I) those which do not carry on the affection and are destined to take part in the formation of sons; and (II) those which do carry on the color-blindness and are destined to form daughters. There is evidence that the ova also are similarly predestined to form one or other of the sexes, but to discuss the whole question of sex-determination is beyond my present scope. The descent of these sex limited affections nevertheless calls for mention here, because it is an admirable illustration of factorial predestination. It moreover exemplifies that *parental polarity* of the zygote to which I alluded in my first address, a phenomenon which we suspect to be at the bottom of various anomalies of heredity, and suggests that there may be truth in the popular notion that in some respects sons resemble their mothers and daughters their fathers.

As to the descent of hereditary diseases and malformations, however, we have abundant data for deciding that many are transmitted as dominants and a few as recessives. The most remarkable collection of these data is to be found in family histories of disease of the eye. Neurology and dermatology have also contributed many very instructive pedigrees. In great measure the ophthalmological material was collected by Edward Nettleship, for whose death we so lately grieved. After retiring from practice as an oculist he devoted several years to this most laborious task. He was not content with hearsay evidence, but traveled incessantly, personally examining all accessible members of the families concerned, working in such a way that his pedigrees are models of orderly observation and recording. His zeal stimulated many younger men to take part in the work, and it will now go on, with the result that the systems of descent of all the common hereditary diseases of the eye will soon be known with approximate accuracy.

Give a little imagination to considering the chief deduction from this work. Technical details apart, and granting that we cannot wholly interpret the numerical results, sometimes noticeably more and some times fewer descendants of these patients being affected than mendelian formulæ would indicate, the expectation is that in the case of many diseases of the eye a large proportion of the children, grandchildren, and remoter descendants of the patients will be affected with the disease. Sometimes it is only defective sight that is transmitted; in other cases it is blindness, either from birth or coming on at some later age. The most striking example perhaps is that of a form of night blindness still prevalent in a district near Montpellier, which has affected at least 130 persons, all descending from a single affected individual[1] who came into the country in the seventeenth century. The transmission is in every case through an affected parent, and no normal has been known to pass on the condition. Such an example well serves to illustrate the fixity of the rules of descent. Similar instances might be recited relating to a great variety of other conditions, some trivial, others grave.

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[*] An address delivered at Sydney, Australia, by Prof. William Bateson, M.A., F.R.S., President, before the British Association for the Advancement of Science.

At various times it has been declared that men are born equal, and that the inequality is brought about by unequal opportunities. Acquaintance with the pedigrees of disease soon shows the fatuity of such fancies. The same conclusion, we may be sure, would result from the true representation of the descent of any human faculty. Never since Galton's publications can the matter have been in any doubt. At the time he began to study family histories even the broad significance of heredity was frequently denied, and resemblances to parents or ancestors were looked on as interesting curiosities. Inveighing against hereditary political institutions, Tom Paine remarks that the idea is as absurd as that of an "hereditary wise man," or an "hereditary mathematician," and to this day I suppose many people are not aware that he is saying anything more than commonly foolish. We, on the contrary, would feel it something of a puzzle if two parents, both mathematically gifted, had any children *not* mathematicians. Galton first demonstrated the overwhelming importance of these considerations, and had he not been misled, partly by the theory of pangenesis, but more by his mathematical instincts and training, which prompted him to apply statistical treatment rather than qualitative analysis, he might, not improbably, have discovered the essential facts of mendelism.

It happens rarely that science has anything to offer to the common stock of ideas at once so comprehensive and so simple that the courses of our thoughts are changed. Contributions to the material progress of mankind are comparatively frequent. They result at once in application. Transit is quickened; communication is made easier; the food-supply is increased and population multiplied. By direct application to the breeding of animals and plants such results must even flow from Mendel's work. But I imagine the greatest practical change likely to ensue from modern genetic discovery will be a quickening of interest in the true nature of man and in the biology of races. I have spoken cautiously as to the evidence for the operation of any simple mendelian system in the descent of human faculty; yet the certainty that systems which differ from the simpler schemes only in degree of complexity are at work in the distribution of characters among the human population cannot fail to influence our conceptions of life and of ethics, leading perhaps ultimately to modification of social usage. That change cannot but be in the main one of simplification. The eighteenth century made great pretense of a return to nature, but it did not occur to those philosophers first to inquire what nature is; and perhaps not even the patristic writings contain fantasies much further from physiological truth than those which the rationalists of the "encyclopaedia" adopted as the basis of their social schemes. For men are so far from being born equal or similar that to the naturalist they stand as the very type of a polymorphic species. Even most of our local races consist of many distinct strains and individual types. From the population of any ordinary English town as many distinct human breeds could in a few generations be isolated as there are now breeds of dogs, and indeed such a population in its present state is much what the dogs of Europe would be in ten years' time but for the interference of the fanciers. Even as at present constituted, owing to the isolating effects of instinct, fashion, occupation, and social class, many incipient strains already exist.

In one respect civilized man differs from all other species of animal or plant in that, having prodigious and ever-increasing power over nature, he invokes these powers for the preservation and maintenance of many of the inferior and all the defective members of his species. The inferior freely multiply, and the defective, if their defects be not so grave as to lead to their detention in prisons or asylums, multiply also without restraint. Heredity being strict in its action, the consequences are in civilized countries much what they would be in the kennels of the dog-breeder who continued to preserve all his puppies, good and bad: the proportion of defectives increases. The increase is so considerable that outside every great city there is a smaller town inhabited by defectives and those who wait on them. Round London we have a ring of such towns with some 30,000 inhabitants, of whom about 28,000 are defective, largely, though of course by no means entirely, bred from previous generations of defectives. Now, it is not for us to consider practical measures. As men of science we observe natural events and deduce conclusions from them. I may perhaps be allowed to say that the remedies proposed in America, in so far as they aim at the eugenic regulation of marriage on a comprehensive scale, strike me as devised without regard to the needs either of individuals or of a modern State. Undoubtedly if they decide to breed their population of one uniform puritan grey, they can do it in a few generations; but I doubt if timid respectability will make a nation happy, and I am sure that qualities of a different sort are needed if it is to compete with more vigorous and more varied communities. Everyone must have a preliminary sympathy with the aims of eugenists both abroad and at home. Their efforts at the least are doing something to discover and spread truth as to the physiological structure of society. The spirit of such organizations, however, almost of necessity suffers from a bias toward the accepted and the ordinary, and if they had power it would go hard with many ingredients of society that could be ill-spared. I notice an ominous passage in which even Galton, the founder of eugenics, feeling perhaps some twinge of his Quaker ancestry, remarks that "as the Bohemianism in the nature of our race is destined to perish, the sooner it goes, the happier for mankind." It is not the eugenists who will give us what Plato has called divine releases from the common ways. If some fancier with the catholicity of Shakespeare would take us in hand, well and good; but I would not trust even Shakespeare's meeting as a committee. Let us remember that Beethoven's father was an habitual drunkard and that his mother died of consumption. From the genealogy of the patriarchs also we learn—what may very well be the truth—that the fathers of such as dwell in tents, and of all such as handle the harp or organ, and the instructor of every artificer in brass and iron—the founders, that is to say, of the arts and the sciences—came in direct descent from Cain, and not in the posterity of the irreproachable Seth, who is to us, as he probably was also in the narrow circle of his own contemporaries, what naturalists call a *nomen nudum*.

Genetic research will make it possible for a nation to elect by what sort of beings it will be represented not very many generations hence, much as a farmer can decide whether his byres shall be full of shorthorns or herefords. It will be very surprising indeed if some nation does not make trial of this new power. They may make awful mistakes, but I think they will try.

Whether we like it or not, extraordinary and far-reaching changes in public opinion are coming to pass. Man is just beginning to know himself for what he is—a rather long-lived animal, with great powers of enjoyment if he does not deliberately forgo them. Hitherto superstition and mythical ideas of sin have predominantly controlled these powers. Mysticism will not die out: for those strange fancies knowledge is no cure: but their forms may change, and mysticism as a force for the suppression of joy is happily losing its hold on the modern world. As in the decay of earlier religions Ushabti dolls were substituted for human victims, so telepathy, necromancy, and other harmless toys take the place of eschatology and the inculcation of a ferocious moral code. Among the civilized races of Europe we are witnessing an emancipation from traditional control in thought, in art, and in conduct which is likely to have prolonged and wonderful influences. Returning to freer or, if you will, simpler conceptions of life and death, the coming generations are determined to get more out of this world than their forefathers did. Is it then to be supposed that when science puts into their hand means for the alleviation of suffering immeasurable, and for making this world a happier place, they will demur to using those powers? The intenser struggle between communities is only now beginning, and with the approaching exhaustion of that capital of energy stored in the earth before man began it must soon become still more fierce. In England some of our great grandchildren will see the end of the easily accessible coal, and, failing some miraculous discovery of available energy, a wholesale reduction in population. There are races who have shown themselves able at a word to throw off all tradition and take into their service every power that science has yet offered them. Can we expect that they, when they see how to rid themselves of the ever-increasing weight of a defective population, will hesitate? The time cannot be far distant when both individuals and communities will begin to think in terms of biological fact, and it behooves those who lead scientific thought carefully to consider whither action should lead. At present I ask you merely to observe the facts. The powers of science to preserve the defective are now enormous. Every year these powers increase. This course of action must reach a limit. To the deliberate intervention of civilization for the preservation of inferior strains there must sooner or later come an end, and before long nations will realize the responsibility they have assumed in multiplying these "cankers of a calm world and a long peace."

The definitely feeble-minded we may with propriety restrain, as we are beginning to do even in England, and we may safely prevent unions in which both parties are defective, for the evidence shows that as a rule such marriages, though often prolific, commonly produce no normal children at all. The union of such social vermin we should no more permit than we would allow parasites to breed on our own bodies. Further than that in restraint of marriage we ought not to go, at least not yet. Something too may be done by a reform of medical ethics. Medical students are taught that it is their duty to prolong life at whatever cost in suffering. This may have been right when diagnosis was uncertain and interference usually of small effect; but deliberately to interfere now for the preservation of an infant so gravely diseased that it can never be happy or come to any good is very like wanton cruelty. In private few men defend such interference. Most who have seen these cases lingering on agree that the system is deplorable, but ask where can any line be drawn. The biologist would reply that in all ages such decisions have been made by civilized communities with fair success both in regard to crime and in the closely analogous case of lunacy. The real reason why these things are done is because the world collectively cherishes occult views of the nature of life, because the facts are realized by few, and because between the legal mind—to which society has become accustomed to defer—and the seeing eye, there is such physiological antithesis that hardly can they be combined in the same body. So soon as scientific knowledge becomes common property, views more reasonable and, I may add, more humane, are likely to prevail.

(*To be continued*)

Why Hens Stop Laying in Winter

It is a well established principle among agricultural economists that animals kept for their working abilities must not be allowed to get fat. Recent investigations show that excess of fat is even more injurious, and therefore expensive, in the case of animals kept for breeding purposes. For it has been proved indisputably that invasion by adipose tissue leads to the degeneration of the organs of reproduction.

It is to this phenomenon, says the *Revue Scientifique*, that we must attribute the reduced egg yield of chickens at the end of winter. Though in perfect health and housed under the most sanitary conditions, hens are generally found at this time to be sluggish and laying so few eggs that the cost per egg is enormous.

This condition is the consequence of too great abundance of food during the winter, coupled with lack of exercise due to the narrow limits of the ordinary chicken-run. This is demonstrated by Mr. Brochemin in an article in *L'Acclimatation* which is quoted from by the *Revue Scientifique*. The balance of economy in the fowl's body is destroyed by a provision of grain which is in excess of the amount of energy it is called on to expend. And it is stated that if an autopsy be performed on such a victim of overfeeding there is found to be a general invasion of the tissues by fat, and the ovarian cluster has a limited development, proving that it is by no means in a state of full activity.

"In the liver the invasion may have proceeded so far that fat forms a constituent part of the active cells, whose functioning is thus forcibly interfered with. The same is true of the heart, which seems to have a special predilection for fat.

"The blood does not circulate so quickly, and, since the lungs have a sluggishness due to the same cause, there is not enough oxygen taken into the system to insure the combustion of the fat, and this is increasingly deposited in the tissues. According to a microscopic examination made by Mr. Dieulafoy, the muscular fibers are the seat of alterations more or less pronounced, whose final stage is the transformation of the fibers into a fatty cylinder."

While such extreme conditions are found only, as a rule, in fowl which have been specially fattened for food, the tendency of too liberal feeding is to cause a taking on of fat and cessation of laying. The obvious remedy is to give less food to hens which stop laying. But in practice a delicate balance must be observed, for hens which are prolific of eggs always have great appetites, and naturally need plenty of food for egg production. To avoid the horns of this dilemma, Mr. Brochemin advises a careful selection of rations, with strict limitation of starchy substances, such as maize, rice, and barley, while giving abundance of green food, such as cabbage, boiled clover, sorrel, etc. These act as stimulants of the liver, and thus are an excellent preventive of fat formation. Finally, he advises that the fowls be induced to take exercise, first by having an ample chicken-run, and by mixing their food with straw, etc., so that they will have to exercise when feeding.

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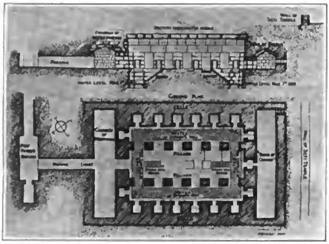
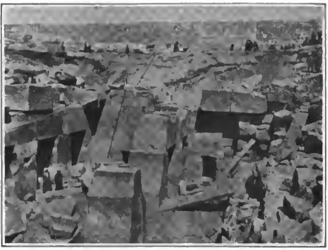
[1] The first human descent proved to follow Mendelian rules was that of a serious malformation of the hand studied by Farabee in America. Drinkwater subsequently worked out pedigrees for the same malformation in England. After many attempts, he now tells me that he has succeeded in proving that the American family and one of his own had an abnormal ancestor in common, five generations ago.



Plan of the ruins at Abydos, showing form of the well, and location of tomb of Osiris.



Cyclopean monolithic pillars and architraves. The wall of the Seti Temple in the background.

The Cyclopean Mystery of Abydos*

The Recent Excavations of Strabo's Well and the "Tomb of Osiris"

By Edouard Naville

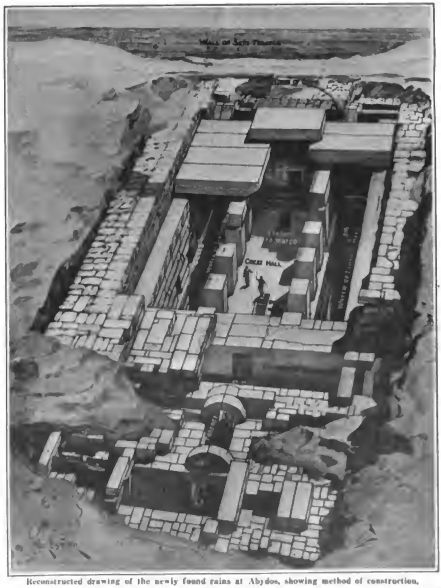
THE excavations made during the winter of 1913-14 at Abydos by the Egypt Exploration Fund under the direction of the present writer, assisted by Prof. Whittemore, from Boston, Mr. Wainwright, and Mr. Gibson, have given quite unexpected results. They have led to the discovery of a building which at present is unique in its kind, and which probably is one of the most ancient constructions preserved in Egypt: a great pool with porches and the tomb of Osiris. It is situate behind the western wall of the temple built by Seti I, which is the chief attraction of Abydos for travelers. It was entirely subterranean, at a depth of more than thirty feet below the temple, and nothing revealed its existence.

The work started from the western end of the construction, from a colossal door-lintel which had been discovered two years ago at the end of a passage covered with funerary inscriptions of King Menephtah, the Pharaoh of the Exodus. This lintel, of much more ancient date than the passage, is a doorway in a wall extending right and left, and of a thickness of more than twelve feet. On the southern side the corner had been reached. The top layers had been discovered of the inclosure wall built in magnificent masonry of hard red quartzite sandstone.

This year's work required a considerable number of workers. It was begun with 450; at the end there were 630, four fifths of whom were boys carrying baskets. The sides of the building had to be traced, and tons of rubbish and loose sand had to be removed from the middle: at the end of eleven weeks the whole structure had been laid bare.

It consists of a rectangle, the inside of which is about a hundred feet long and sixty wide. The two long sides are north and south; east is the side of the temple of Seti; west the doorway with the lintel, 15 feet long, which had been discovered in 1912. The inclosure wall is 20 feet thick. It consists of two casings; the outer one is limestone rather roughly worked; the inner one is in beautiful masonry of red quartzite sandstone. The joints are very fine; there is only a very thin stratum of mortar which is hardly perceptible. Here and there the thick knob has been left which was used for moving the stones. The blocks are very large—a length of 15 feet high is by no means rare; and the whole structure has decidedly the character of the primitive constructions which in Greece are called cyclopean, and an Egyptian example of which is at Ghizeh, the so-called temple of the Sphinx.

This colossal character is still more striking in the inner part. It is divided into three naves or aisles of unequal size, the middle one being wider. These naves are separated by two colonnades of square monolithic pillars in granite about fifteen feet high and 8½ feet square. There are five of them in each colonnade. They supported architraves in proportion with them, their height being more than six feet. These architraves and the inclosure wall supported a ceiling, also of granite monoliths, which was not made of slabs, but of blocks, like the architraves, more than six feet thick. It has been calculated that one of the few of them remaining weighs more than thirty tons. Unfortunately, in one corner only has the ceiling been preserved. The whole building has been turned into a quarry, especially the inside, which was entirely granite. Pillars, architraves, ceiling, everything has been broken and split



Reconstructed drawing of the newly found ruins at Abydos, showing method of construction.

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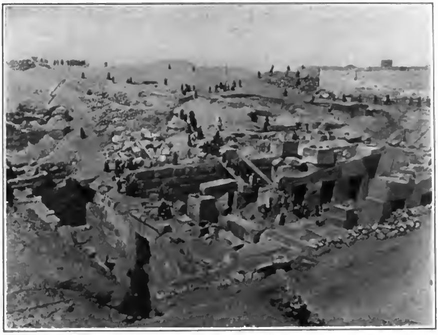
* Reproduced from the *Illustrated London News*.



Uncovering the ruins at Abydos.

with wedges, traces of which are seen everywhere, in order to make millstones of various sizes. Several of them, weighing seven or eight tons, have been left.

The side aisles only, about ten feet wide, had ceilings. It is doubtful whether the middle nave was roofed. It was, perhaps, only covered at the end over the entrance to the "tomb of Osiris." When the work reached the lower layers of the inclosure wall, a very extraordinary discovery was made. In this wall, all round the structure, are cells about six feet high and wide, all exactly alike, without any ornament or decoration. They had doors, probably made of wood, with a single leaf; one can see the holes where they turned. Such cells are not seen in any other Egyptian construction.

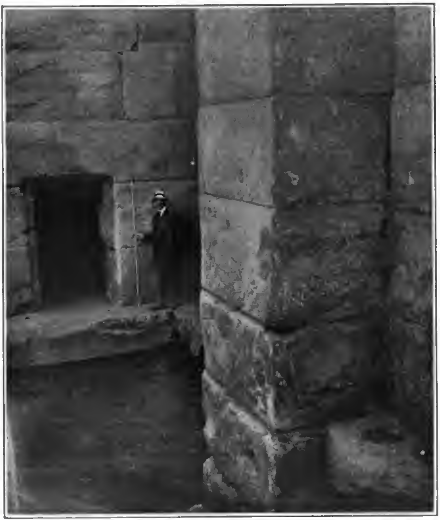
What was still more surprising is that they do not open on to a floor, but onto a narrow ledge which run on both sides of the nave. There was no floor in those aisles; under the ledge, which is slightly projecting, the beautiful masonry goes on, and at a depth of twelve feet water was reached. It is at the level of the infiltration water in the cultivated land, though the structure is in the desert. This year the Nile is lower than it is known to have been for more than fifty years. Were the river at a normal height, the water would reach the ledge, which is below the cultivated land. Thus the two aisles and the two ends of the middle nave form a continuous rectangular pool, the sides of which are very fine masonry of large blocks. How much deeper the wall goes than the present level of the water, it is difficult to say; but it probably goes down for another twelve feet. The excavations of next year will reveal what there is at the bottom. It was not possible this year to go farther because of the great number of granite blocks thrown into the pool. They will have to be hauled out, for among them may be statues or fragments of them.

The middle nave is a block of masonry also made of enormous stones, which goes down as deep as the water, and on which rests the pillars of the colonnades. The floor is at the same level as that of the cells and of the ledge. This platform is an island: it could be reached only with a small boat or by a wooden bridge; there is water on the four sides. Even in front of the doorway there is only the ledge; there is no pathway of any kind leading to it. On both sides—east and west—there are two staircases leading from the platform to the water. The last step is about three feet above the present level of the water. In a normal year the two or three last steps would be covered.

The middle nave ends on the east side, the side of the temple of Seti, with a high wall on which are religious sculptures, the only ones in the whole building. They represent offerings made by Menephtah to Osiris and other gods; and the two important amulets which were generally worn or are found on the mummies. This showed that there was behind the wall something of a funerary character, the tomb of Osiris, perhaps. Osiris, although he was a god, was supposed to have been torn to pieces by his enemy, Set or Typhon, and his limbs had been scattered among the chief cities of Egypt. Abydos being the residence of the god, its share had been the head, which was buried in his tomb. That tomb was very famous, and various excavators have been searching for it for years. When the lower part of the end wall of the nave was cleared, there appeared the door of a cell quite similar to the other ones. The back wall of this cell had been broken through in order to make an opening, a door which had been blocked afterwards with stones. It gave access to a large subterranean chamber, wider than the whole construction, very well preserved, with a ceiling consisting of two slabs leaning against each other. On the ceiling and on the side walls are funerary representations like those of the tombs of the kings. It is evidently a tomb, and the sculptures show it to be what was regarded as the tomb of Osiris. The chamber was quite empty except for a heap of sand in one of the corners. When this had been removed, it was found that the sand came through a hole used by robbers. There was no sarcophagus nor object of any kind. It is not to be supposed that anything of that sort can be found in a construction used for centuries as a quarry.

The tomb of Osiris is of a later date than the pool with its cells. It dates from the time of Seti I, the grandfather of Menephtah, who probably made it when he built his temple. As for the pool, it is probably one of the most ancient constructions which have been preserved in Egypt. It is exactly in the style of the so-called temple of the Sphinx, which is a work of the Fourth Dynasty, and one of the characteristic features of which is the total absence of any inscription or ornament. But the pool is even more colossal. In the temple of the Sphinx the pillars are 4 feet square; here they are 8½. It is impossible, in spite of the havoc made, especially in the southern aisle, not to be struck by the majestic simplicity of the structure, chiefly in the corner where the ceiling has remained. Besides, this construction of a character quite unknown at present raises many questions which further excavations will, perhaps, solve. Was the pool in connection with the worship of Osiris? Did the sacred boat of the god float on the water? Since the boats of the gods are always towed with ropes, the ledge on both sides would be a very appropriate path for the priests who did it. What were the cells made for? Were they reproductions of those which the Book of the Dead describes as being in the celestial house of Osiris? Was the water supposed to have a curative effect; was it an Egyptian Pool of Bethesda?

As for the water itself, it must have been stored for some purpose. The enormous ceilings must have been made in order to prevent evaporation. Is it to be imagined that the old Egyptians made such an enormous construction merely for infiltration water? There is no



Huge masonry of one of the most ancient constructions known in Egypt. Showing ledge that surrounds Strobo's Well and the doorway to one of the cells. This view is in the southwest corner, indicated at B on the plan.

doubt that it is what is called Strabo's Well, which he describes as being below the temple, and like the Labyrinth at Hawara, but on smaller proportions, and with passages covered by big monoliths. Was there a canal coming from the Nile, as the Greek geographer says, or was the pool filled by the subterranean sheet of water which flows under the desert, the so-called underground Nile which is now being studied closely by the hydraulic engineers of Egypt? These are a few questions which arise from this discovery; and it is, therefore, most desirable that the generosity of the friends of the Egypt Exploration Fund may provide the society with the necessary financial means for completing this highly interesting and important work.

Mines in Naval Warfare*

Their Use in the Russo-Japanese Struggle

The mine as an instrument of naval warfare is by no means so modern a contrivance as most people seem to imagine. Its first recorded appearance was at the siege of Antwerp in 1585, when the Dutch employed floating mines, exploded by means of clockwork connected to a matchlock arrangement, against the Spaniards with great success. Similar contrivances were employed by the English at the siege of La Rochelle in 1628, but with much less effect.

In the American Revolutionary war the submarine mine (as distinguished from floating contrivances of that nature) made its *début*. An American inventor named Bushnell made two attempts to destroy British war vessels by the agency of submerged kegs filled with gunpowder, and designed to explode on contact with other objects. These seem to have acted well, but partly owing to vigilance on the part of the British, and partly through the mines being set adrift at too great a distance from their object, no great damage was accomplished.

In the first few years of the nineteenth century the American inventor Fulton endeavored to find a market for a form of submarine mine with the French, and later with the British, then engaged in the Napoleonic struggle. Owing to their being too near the surface these mines did no harm to ships of the French fleet off Boulogne, against which they were tried in 1804; and though Fulton demonstrated the possibilities of his invention with more success on a brig off Walmer in the following year, he could not induce the British naval authorities to take it up as a permanent engine of war. He carried out further experiments in his own country in 1810, but afterward devoted his energies to other objects.

The Russians attempted to destroy ships of the British and French fleets by means of mechanical mines during the Crimean war, and actually succeeded in exploding one beneath H.M.S. "Merlin," but the charge used was so small that no serious damage was caused.

During the American civil war various forms of mines were used by the Confederates, and several Federal vessels were lost from this cause. As a result electrically controlled mines were adopted in this country in the early seventies; but it is only in comparatively recent years that any great use has been made of mechanical mines, notably in the Russo-Japanese war, when they played a most prominent part.

After the Japanese torpedo attack on the Russian fleet at Port Arthur on the night of February 7th-8th, 1904, the Russians realized the likelihood of the Japanese attempting an attack and landing troops (as they ultimately did) at Dalni, and to protect that port the minelayer "Yenesei" proceeded to lay a large number of mechanical mines in Talien Bay during the 9th, 10th, and 11th of February, 1904. On the third day, while attempting to destroy a mine which had broken loose from its anchorage and was floating on the surface, the "Yenesei" was very effectually hoisted by her own petard, and was lost with over ninety lives. The light cruiser "Boyarin" dispatched to investigate this occurrence, struck a mine when about to anchor, and subsequently sank, thus giving an early illustration of the dangers which this type of mine presents to those employing it.

Notwithstanding these discouragements, Rear Admiral Loschinski laid some eight hundred mines in Talien, Kerr, and Deep Bays during the second half of February, and though many were afterward found to have been laid at unsuitable depths, they were wisely considered too dangerous to interfere with.

In April the Japanese took a hand in the game, employing specially fitted merchantmen, destroyers, and torpedo boats for the work of laying mines. They devoted their energies to placing groups of mines in positions over which the Russian ships usually passed when maneuvering outside the harbor, and on April 13th the Russian fleet, coming out hurriedly to rescue one of their destroyers which was in danger of being cut off, came into this area. The flagship "Petropavlovsk," with Admiral Makaroff and the greater part of her crew of 700, was sunk; and soon afterward the "Pobeida," another battleship, was damaged on passing over another minefield, causing something approaching panic among the other Russian ships, who for the moment imagined themselves attacked by submarines.

On April 28th Japanese destroyers laid seventy-five mines in three groups outside of Vladivostok, as the result of which the Russians were deterred from using Ussuri Bay for some time afterward. A German steamer conveying coal to Vladivostok was sunk by one of these mines in June, and another in July. The Russians also lost a torpedo boat here by this cause in the latter month. In August one of their cruisers suffered damage from a mine while coming out from Vladivostok.

Meanwhile the Russians had not been idle. They laid two groups of mines to protect the entrance to the harbor at Port Arthur from attempts to block it, and several of the ships employed in the Japanese attack of May 3rd came to grief on these. A Japanese torpedo boat was destroyed while sweeping for mines in Kerr Bay, and on May 14th the Russian minelayer "Amur" (sister to the "Yenesei") succeeded in laying unobserved a number of mines about ten miles southeast of Lao-ti-Shan, outside territorial waters. This enterprise resulted more successfully than the Russians could have dared to hope, for the very next day the battleships "Hatsuse" and "Yashima" (the former flying the flag of Rear Admiral Nashiba) both struck mines and sank—the "Hatsuse" in a minute and a half, the "Yashima" after some hours spent in endeavoring to tow her to a place where she could be beached. Nor did this exhaust the list of Japanese misfortunes, for on May 14th the gunboat "Miyako" struck a mine in Kerr Bay and sank in twenty-three minutes, and on the 17th the destroyer "Akatsuki" met with a similar fate while on guard duty outside Port Arthur.

From this time onward both sides continued industriously to lay mines, at intervals desisting to sweep for those laid by their opponents. In June the "Amur" was disabled, thus depriving the Russians of their only remaining minelayer, and forcing them to rely on improvised vessels for this work. By this time they had organized a flotilla of steam hoppers for use as mine sweepers and also employed destroyers for that purpose.

During the Russian sortie from Port Arthur on June 23rd the battleship "Sevastopol" was severely damaged by a mine. By this time Talien Bay, after several weeks' work, had been practically cleared of mines by the Japanese, and their troops were able to disembark at Dalni, but stray mines still continued to give trouble. On July 5th the Japanese gunboat "Kaimon" was lost through striking one off Dalni, and on the 28th the cruiser "Chiyoda" was nearly sunk by a mine which exploded near her bow, and was with difficulty patched up enough to be taken back to dock in Japan. This was more than counterbalanced on the following day, when the "Bayan," the most enterprising of the larger Russian ships, had her foremost compartment flooded by the explosion of a mine under it when entering the harbor, and was obliged to dock for repairs, being thus unable to take part in the battle of August 10th. On the same day one of the steam hoppers belonging to the Russian mine-sweeping flotilla was sunk by a mine.

No further losses of capital ships took place on either side from mines during the war, probably owing to the greater precautions taken; but in the battle of August 10th, which resulted in the dispersal of part of the Russian fleet, and the retreat of the rest to harbor again, its movements were greatly hampered at the outset by the necessity for sweeping every yard of the water ahead of it before it could proceed, and its chances of getting through to Vladivostok were thus greatly lessened.

No more eloquent testimony of the part played by mines in the Russo-Japanese war could be sought than the appended list (based on the official history of the conflict) of losses sustained by both sides from this cause up to the fall of Port Arthur. If the Germans in the present war are employing mines as freely as is believed, the people of Great Britain must be prepared to face losses equally heavy with equanimity. The action of the "Konigin Luise" in laying mines outside territorial waters had its precedent in the Russo-Japanese war, but there were not a few criticisms of the action of both sides, at that time and subsequently, when merchant vessels continued to strike mines for quite a long time after peace had been concluded. It is true the Chinese were the chief sufferers, but some European vessels also fell victims to the casual ways of the combatants in strewing mines broadcast without any provision for their being rendered harmless if they broke loose. It is to be sincerely hoped that we shall not have a similar experience after the conclusion of the present struggle.

LIST OF RUSSIAN SHIPS LOST BY MINES, 1904-5.

"Yenesei" (armed minelayer), by own mines, February 11th, 1904.

"Boyarin" (light cruiser), by Russian mine, February 14th, 1904.

"Petropavlovsk" (battleship), by Japanese mine, April 13th, 1904.

Torpedo-boat "No. 208," by Japanese mine, outside Vladivostok, July 17th, 1904.

"Gremyashchi" (armored gunboat), near Port Arthur, August 18th, 1904.

"Vuinoslivi" (destroyer), near Port Arthur, August 24th, 1904.

"Stroini" (destroyer), outside Port Arthur, November 13th, 1904.

LIST OF JAPANESE SHIPS LOST BY MINES, 1904-5.

Torpedo boat "No. 48," in Kerr Bay, May 12th, 1904.

"Miyako" (large gunboat), in Kerr Bay, May 14th, 1904.

"Hatsuse" (battleship), May 15th, 1904.

"Yashima" (battleship), May 15th, 1904.

"Akatsuki" (destroyer), May 17th, 1904.

"Kaimon" (large gunboat), outside Talien Bay, July 5th, 1904.

"Otagawa Maru" (improvised gunboat), August 8th, 1904.

"Hayatori" (destroyer), September 3rd, 1904.

"Heiyen" (armored gunboat), September 18th, 1904.

"Saiyen" (light cruiser), November 30th, 1904.

"Takasago" (light cruiser), December 12th, 1904.

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* Reprinted from the *Naval and Military Record* of August 19th, 1914. London, England.

The Impurities of Coal Gas

A New Method of Extracting the Sulphur Present

One of the most interesting papers presented at the fifty-first annual meeting of the Institution of English Gas Engineers held in Liverpool from June 16th to 18th was read by Dr. Charles Carpenter of London, and dealt with a new method of removing the carbon-bisulphide (CS_2), one of the most troublesome impurities of coal gas. The sulphur that finds its way into the gas from the coal is present in one of two forms, either in combination with hydrogen as sulphureted hydrogen (H_2S), or in combination with carbon as carbon-bisulphide (CS_2). The former is easily removed from the gas by passing over hydrated ferric oxide, the latter can only be removed by first converting it into the form of sulphureted hydrogen, and by then absorbing this gas in ferric oxide in the usual manner.

The interest of this process for the general public lies in its relation to the weight of sulphur that is brought into their houses and homes with the gas used for illumination purposes (gas heating and gas cooking stoves are connected to chimneys, or ought to be), and to the harm that is done to delicate fabrics and decorations by the sulphuric acid, which is ultimately formed on its combustion. Assuming that only 20,000 cubic feet of gas are employed in an ordinary house for illuminating purposes during the six winter months, when good ventilation is not possible, and that this gas contains 24½ grains sulphur in each 100 cubic feet, three quarters of a pound of the latter element will be contained in this amount of gas, and on combustion will yield 3 pounds of sulphuric acid, or oil of vitriol. Dr. Carpenter has clearly recognized that so long as this charge of contamination and damage can be brought against gas, the rivalry of the electric light will be keen, and in some districts successful; and it is for the purpose of putting the gas companies and undertakings in a stronger position to meet this competition, that he has revived and developed a method of breaking down and removing the carbon-bisulphide by catalytic action.

Many attempts have been made in the past to introduce into the gas-making industry, methods and apparatus for removing the carbon bisulphide by catalysis, and at the Portland (Oregon) Gas Works, Messrs. Hill and Papst are now operating a process which enables over 70 per cent of the sulphur to be removed. Carpenter's own work on the subject commenced in 1906, and was carried out in ignorance of the Portland results. The method used is based upon the conversion of the carbon-bisulphide into sulphureted hydrogen by heating the gas to a temperature of 400 deg. Cent., and by then passing it through tubes filled with fire-clay balls coated with metallic nickel in a finely divided state, and maintained at a temperature of 450 deg. Cent. At this temperature the finely divided metallic nickel acts as a catalytic agent, and brings about the following reaction, without itself undergoing any chemical change:

$$\begin{array}{ccccccc} CS_2 & + & 2H_2 & = & 2H_2S & + & C \\ \text{carbon-bisulphide} & + & \text{hydrogen} & = & \text{sulphureted hydrogen} & + & \text{carbon} \end{array}$$

The carbon remains as a deposit of soot on the fire-clay balls, and at stated intervals it is necessary to pass air through the reduction tubes, in order to burn off this deposited carbon.

This method of converting carbon-bisulphide into sulphureted hydrogen was first suggested by Vernon Harcourt, the eminent English scientist, in 1870, but the practical difficulties in the application of the process to the gas-making industry were very great, and only Hill and Papst in America, and Carpenter in England, have been able to overcome these with any degree of success. Carpenter works his process at a lower temperature than the American one, and in this way avoids any depreciation of the illuminating or thermal properties of the gas. By preheating the gas to 400 deg. Cent. before permitting it to enter the reaction tubes containing the catalytic agent, he is enabled to reduce the time required for the reaction, and to increase its efficiency, while by use of a cheap nickel salt (the chloride) for impregnating the fireclay balls, he keeps down the capital outlay required for equipping a purifying plant capable of dealing with large volumes of gas. A plant with a capacity sufficient to deal with the whole of the production has already been erected at the Old Kent Road (London) and East Greenwich Works of the South Metropolitan Gas Company, and the following figures summarize the results obtained at these two works since the new purification plant was installed:

Old Kent Road, London.
January, 1913, to May 31st, 1914.

Total volume of gas treated, 2,335,776,000 cubic feet.

Sulphur, before treatment by new process, 39.74 grains per 100 cubic feet.

Sulphur, after treatment by new process, 8.33 grains per 100 cubic feet.

Percentage reduction of sulphur, 79.3 per cent.

East Greenwich, London.
April and May, 1914.

Total volume of gas treated, 483,888,000 cubic feet.

Sulphur, before treatment by new process, 35.07 grains per 100 cubic feet.

Sulphur, after treatment by new process, 7.82 grains per 100 cubic feet.

Percentage reduction, 77.7 per cent.

Thus, nearly three thousand millions of cubic feet of gas have been treated by the new purification process since January, 1913, with an average reduction of nearly 78 per cent, and at an average cost of only 0.290 pence (0.598 cent) per 1,000 cubic feet.

In conclusion, it may be stated that Dr. Carpenter is president of the South Metropolitan Gas Company, the company which shares with the Gas-Light & Coke Company, the duty of providing the seven millions and odd inhabitants of London and its suburbs, with gas. Dr. Carpenter controls works employing 8,000 persons, and it was his company which twenty-five years ago, under the wise guidance of Sir Charles Livesey, initiated the system of profit-sharing that has been adopted by all the larger gas undertakings of the United Kingdom. It is no doubt true that *at present*, the managers and engineers of gas undertakings are not convinced that the large amounts of sulphur present as an impurity in their gas, handicap them in their efforts to gain new customers, or to retain the old ones. But the South Metropolitan Gas Company with Dr. Carpenter at its head, has given a lead to the other gas companies of the United Kingdom and of America, which is worthy of imitation.

The competition of electricity with gas is keen and will increase, especially where the electricity supply people can point to the damage done by the sulphur contained in gas. The writer will not be in the least surprised, therefore, if twenty-five years hence, all gas works managers and engineers are as keen about "purification," and the necessity for reducing the sulphur and other impurities contained in their gas to the lowest practicable limits, as they are now on the hire and sale of stoves and fires, and on the increase of their heating and cooking load. It will then be Dr. Carpenter's turn to smile.

The South Magnetic Pole has not yet been definitely located, according to recent reports from Dr. Mawson's Australasian Antarctic expedition. Heretofore it has been assumed that Dr. David visited this pole in the course of Shackleton's expedition, in 1909, but according to Mawson's recent investigations the spot reached by David, although lying within the region in which the magnetic needle is at times vertical, is not the center of that region, which appears to be of much greater extent than was formerly supposed. Moreover, there appear to be several local poles around the principal pole. One of these is supposed to lie near a region visited by Mawson southeast of Adélie Land.

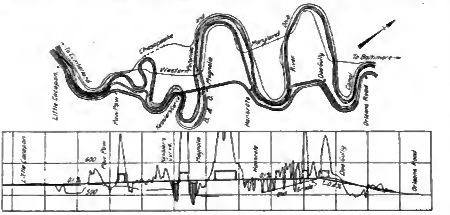
The Magnolia Cut-Off

An Improvement on the Baltimore & Ohio Railroad Costing Millions

By Harry C. Plummer

Up on the western watershed of the Blue Ridge Mountains, where the giant Mallet locomotives strain and tug at heavily laden freight trains, the Baltimore & Ohio Railroad has recently completed a $6,000,000 eleven-mile cut-off that ranks among the great engineering feats of American railroading.

The Magnolia cut-off improvement, between Orleans Road and Little Cacapon, W. Va., work upon which was started in May of last year (1913), accomplishes for the B. & O. two distinct economic advantages. It effects a saving of 5.8 miles in the length and 887 degrees of curvature of the eastbound tracks and does away with a sharp grade at Hansrote, which has required the use of pusher engines for eastbound traffic climbing the mountains at that point. Secondly, it completely equips the B. & O. as a three-track and four-track system east of Cumberland, Md., to Martinsburg, W. Va., and, in conjunction with extensive track additions on the mountain divisions, effected during the last three years, provides ample facilities to care for the almost indefinite future.



Map and profile of the Magnolia cut-off.

Factors of economic operation were directly responsible for the Magnolia cut-off improvement being undertaken by the Baltimore & Ohio Railroad. Embraced in a general economic study of its operation is the plan eventually to overcome the high operating costs in mountainous country by revising its line, reducing grades, eliminating curvature, and doing away with helper-engine service on that section of the line eastward from Cumberland, Md.

The plan contemplates a four-track system of 105 miles, from Cumberland to Brunswick, the point of intersection of the Cumberland and Baltimore divisions. In fact, the ultimate plan is to continue the four-track line to the seaboard at Baltimore, with the construction of third and fourth tracks from Brunswick to Washington Junction, Md., where two two-track lines converge toward Baltimore, one by way of Washington, the other through Frederick County. So, when it was determined to build the Magnolia improvement, the railroad began to "open the neck of the bottle."

The east end of the Cumberland division of the Baltimore & Ohio Railroad is known far and wide in railroad circles as the most congested stretch of railroad line in the United States. Two main lines, one from Chicago, the other from St. Louis, converge at Cumberland, with the bulk of their tonnage gathered from innumerable sub-main and branch lines. Most of this business is for seaboard movement to Washington, Baltimore, Philadelphia, New York, or New England. The question of keeping the trains moving with sufficient regularity to avoid blockades has long been one of moment and a problem calling for the most efficient operating methods.

The daily average train movement over the line is eighty-five trains of all classes, consisting of fast and local passenger trains, through, local and pick-up trains, and numerous work trains and contractors' equipment, and of this there is an average of seventy freight trains daily. Another factor in the operation of the line under conditions prevailing before the improvements were undertaken was the diversity of traffic, both with respect to volume and class of business, and many incidents occur which tend to bring on an abnormal movement of one grade or other of traffic.

While it has not been fully decided how the new line shall be used, it is generally believed that the two new tracks will be devoted to eastbound trains, and the old line turned over exclusively to westbound trains, this being the original idea when the line was surveyed.

So quietly has work progressed upon the cut-off that traffic upon the old tracks has not been at all interrupted and, by day and by night, the passengers on local and limited trains have been swept past the scene of the big improvement for the most part unmindful of the task the engineers have forged to a successful conclusion.

The greater part of the excavating has been done through solid rock. The slopes of the embankment, at river approaches, have been protected by concrete retaining walls, and the slopes along the hillsides terraced to obviate all danger from slides or falling rock.

Diverging from the eastbound side of the old three-track line west of Orleans Road, the cut-off line rises on a 4 per cent compensated grade for 4,500 feet to a point where it crosses the old line at grade. From that point it continues to rise on the same grade through the ridge at Doe Gully, where the tunnel of bygone days has been converted into an open cut.

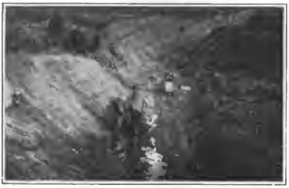
Briefly described, the improvement begins at Orleans Road. Four new tracks have been constructed, with gradients slightly less than those of the present tracks, through the summit at Doe Gully, removing the present tunnel and lowering the grade at the summit about ten feet. From Doe Gully the old track has been maintained for the westbound movement to Paw Paw. The new tracks have been constructed along the hillside above the older roadbed to a point just east of Hansrote, where they diverge to the left, passing through the ridge just east of Magnolia, crossing the present tracks overhead and the Potomac River at Magnolia, cut through the ridge on the west side of the river, and again crossing the present tracks at Kessler's Curve, overhead. The line then follows the hillside above the old tracks to a point just west of Paw Paw, where they again diverge to the left, passing through the ridge south of the old Paw Paw tunnel, by a short tunnel, and through the high ground just south of Paw Paw in an open cut, and coming out on the bank of the river just above the present tracks. From that point to Okonoko a four-track line has been constructed on a grade slightly higher than the present tracks, and above the elevation of the highest water heretofore known in the Potomac. As part of the automatic signal apparatus with which the line will be equipped, interlocking plants will be installed at Doe Gully, Magnolia, Little Cacapon, and Great Cacapon.

The improvement has cost approximately $6,000,000 and the operations have extended over a period of fourteen months.

Francis Lee Stuart, chief engineer of the Baltimore & Ohio Railroad, with headquarters at Baltimore, is in charge of the improvement.

Concrete retaining wall on river embankment, viewed from present roadbed.

The conquest of mountain and hillside by the Baltimore & Ohio Railroad enginee
looking north fr



Easterly approach of cut to Paw Paw tunnel, on center line, near Station No. 1870.

Newly completed roadbed, showing shovel, traveler, and wall; below, the old roadbed on river bank.

The chaos of earth and
symmetrical lines

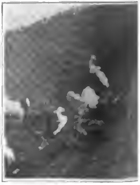
Present tracks, eastward from Station No. 1840 (Section 6).

A cut through a bit of table-land, high above the river level.

Ready for the heavy traffic
from Stations

East approach to Stuart Tunnel. A battle against unyielding rock of the Blue Ridge.

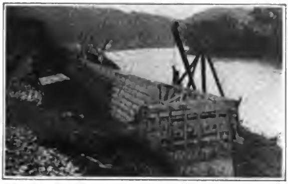
Drilling and cutting the westerly approach to the Stuart Tunnel.



Shovel force penetrating the
looking east

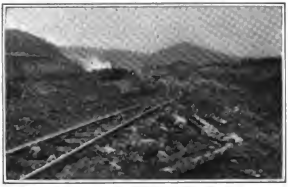
THE MAGNOLIA CUT-OFF ON THE

At work on the Magnolia cut-off; view of the north side of the Doe Gully Cut, Station No. 1543.

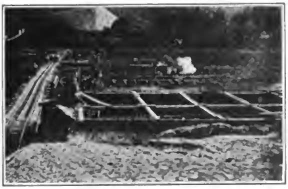


Another view of retaining wall built to guard against periodical rise of the Potomac.

ck whence has sprung the
the Magnolia cut-off.

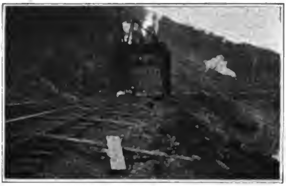


A comparatively open space on the Magnolia cut-off, south of Station No. 1921.

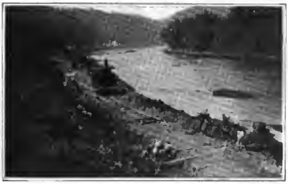


Bridging the winding Potomac at Magnolia for a short cut through the ridge seen opposite.

e imposed upon it; westward
1936 and 1955.

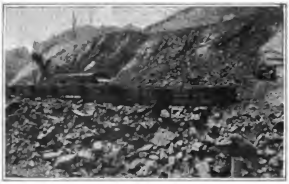


Traveler for erection of inner track wall at work on Section No. 6.

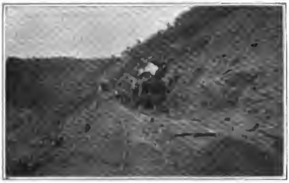


Laying the foundation for retaining wall west of Station No. 1933.

lid rock on Section No. 6
top of slope.



Middle Bench, Doe Gully Cut, north side, viewed westward from Station No. 1544.



Top Bench, Doe Gully Cut; below, the present two-track line, Baltimore & Ohio Railroad.

BALTIMORE & OHIO RAILROAD

The Baltic and Black Sea Canal Scheme*

An Improvement of Immense Importance to the Commerce of Central Russia

The project for joining up the natural waterways between the Baltic and the Black Sea by the construction of artificial connecting channels has recently made an important advance. Although primarily intended for the development of commerce, the strategic value of such a connection between the great seas to the north and south of Russia will not be lost sight of, in view particularly of the demonstration of the value of the Kiel Canal in the German scheme of naval tactics. Thus an impetus will be given to the Russian project, which cannot be without great influence on the present study of the report of the Government Commission appointed to investigate the whole subject. This commission, which was appointed by the Duma and Senate four years ago, while intended to make a comprehensive survey of the whole scheme of internal navigation in Russia, was required to give primary consideration to the Baltic and Black Sea Canal scheme, and particularly the proposal to construct locks to circumvent the rapids on the great southern river, the Dnieper, which rapids at present check the complete utilization of this great natural waterway, piercing northward from the Black Sea into the very heart of European Russia. With its tributaries it affords navigable channels of nearly 4,000 miles, excepting for the obstructing rapids near the mouth. The canalization, for moderate-sized ships, of a connection between the river north and south of these rapids, now decided upon, must itself have a very important influence on the internal trade of Russia, apart altogether from the advance which would thereby be made toward the realization of the main project of water communication between the Baltic and the Black Sea.

A study of the map of Russia shows that the rivers of European Russia flow over great, broad plains between the two ranges of the Carpathian Mountains in the west and the Ural Mountains in the east, and that between the Baltic and the Black Sea two of the principal rivers are the Dnieper and the Dwina, the former, as we have said flowing into the Black Sea at Kherson and the latter into the Gulf of Livonia at Riga and thence into the Baltic Sea. These rivers, too are navigable for small craft for great distances into the interior, although in the case of the Dnieper there are rapids, owing to the great step-like formation, between the towns of Ekaterinoslav and Aleksandrovsk, some 200 miles from the mouth of the river, and in the case of the Dwina in the last 100 miles or so from the mouth to Jacobstad. As will presently be explained, there are projects for instituting electric-power generating-stations at the falls in both instances; but the necessity for navigation will be the primary consideration, the harnessing of waterfalls being subsidiary and contingent upon the requirements of shipping.

The sources of the two rivers at the "divide" are not far apart and the idea of connecting them by artificial waterways occurred to Peter the Great, who called in a Dutch expert to make a survey of possible routes through which canals could be constructed. Catherine II. supported this work of survey, but it was not until Russia had absorbed the Polish provinces that any material progress was made with the project. The canals then made, early in the last century, were intended for flooding purposes, and not really for shipping. Within the last twenty years, schemes for a deep canal without locks have been worked out, but the authorities considered the scheme impracticable from the financial point of view. Ultimately, as the result of private initiative, a company was formed and laid a scheme before the government for the construction of a waterway free from locks, and with a depth throughout the navigable channel of 14 feet. The main aim was to develop interior trade, and at the same time to afford a means of transit for merchandise passing through the Suez Canal to the countries on the shores of the Baltic and the Black Sea ports. It was proposed in this project to use large boats with motors, which would receive the goods at the terminals of the canal and deliver them either on the waterway or to large ocean-going vessels at the other end. At the same time the strategic value of the canal was recognized, but the scheme did not then meet with sufficient support. Now, however, owing to the more liberal constitution which has been introduced into Russia, and when more attention is being devoted to trade and commerce, there is greater prospect of the government recognizing the value of such an opening up of the natural resources and industrial potentialities of the interior of European Russia. Last year a large number of members of the Duma took the initiative for the actual completion of the Baltic-Black Sea Canal; they urged that exhaustive plans of the entire waterway, at the instance of the Public Works Department, should be ready at the beginning of 1914, and that from next year the Budget of this department should contain annual grants sufficient for the completion of this waterway in the course of five years.

The scheme which commends itself is that to which we have already referred—namely, the joining of the upper waters of the Dnieper and the Dwina, thus connecting Kherson, on the Black Sea, with Riga, on the Baltic. The length of such a waterway would be about 1,540 miles. The Dwina extends southward from the Riga port on the Baltic for a distance of 625 miles. Formerly there was a very extensive use of this waterway for barges, of which 21,000 annually traded to Riga with corn and other products from the upper reaches of the river. These barges had a carrying capacity of about 225 tons, and were carried down with the stream when the melting snow created a spate, but they were of little use for carrying supplies up country. Railway competition soon killed this method of transport, and now sailing vessels of from 10 tons to 80 tons or 90 tons capacity are used, and are navigated in both directions. Under these circumstances, the traffic has not increased greatly (except for the floating down of timber, to be made into rafts for shipment at Riga). In the upper reaches, however, for a distance of some 390 miles or so, steamers are in use, while for 940 miles, in tributaries and in navigable channels connected with the River Dwina, small steamers can be navigated. The river, from Bitebsk to Riga, a distance of about 370 miles, has a total fall of 348 feet, but the greater portion of this, as already indicated, is in the lower part of the river. The proposals for three hydro-electric power-stations—one of 4,000 horse-power and two of larger power—have been made in association with the canal parallel to the rapids; but, as has already been indicated, these will be subject to the main idea of making a canal through to the Black Sea. It may be said that from the upper Dwina a waterway debouches and communicates with St. Petersburg, but no survey has been made, although it is understood to offer no special difficulty in the way of development for navigation.

It is proposed to make a connection between the upper navigable part of the Dwina and the upper navigable part of the Dnieper, not by using the abandoned canals made 110 years ago, but by following the course of a tributary of the Dwina and one of the Dnieper near the watershed, which is some miles to the west of Smolensk. In the uplands there are two lakes which would be most useful for the feeding of the canals on each side of the water divide. The level of the water of the Dwina at Vitebsk is about 70 feet lower than that of the Dnieper at the most suitable point of junction. The distance between the rivers to be canalized is under 60 miles, and the proposal under consideration provides for three locks for the Dnieper and eight for the Dwina from the highest point. The cost of this canal, with wooden locks, is estimated at about 19 million roubles, and with stonework locks 6½ million roubles more.

The Dnieper, which is the third largest river in Europe, the Volga and Danube excelling it, has a length of nearly 1,350 miles, and in its course there is a population of something like 20,000,000. With the tributaries the total waterway is nearly 8,000 miles, of which about one half is navigable for small vessels. The products of the district are corn, timber, ore and coal, and undoubtedly there would be a great development of the natural and mineral wealth were the route to the sea improved. The obstacle, as we have mentioned, is the rapids between Ekaterinoslav and Aleksandrovsk. The largest vessels using the river below the rapids have a capacity of about 1,000 tons, and more than 300 steamers and 1,200 sailing craft are engaged in the service. Above the rapids the river, so far as it is to be used on the route, from sea to sea, is navigable for a distance of over 800 miles, and beyond this it is proposed to use the Beresina and the new canals already referred to. The Beresina is about 200 miles long and has a fall of about 90 feet, and it is proposed to canalize this portion with fourteen locks. Beyond this, as already indicated, there will be the canals connecting with the Dwina River, flowing into the Baltic. Although in the upper navigable part of the Dnieper there is a fall of 200 feet in 500 miles, it is thought that it would be practicable to make it navigable for larger vessels without locks, by means of regulation works and dredging. For 100 miles of the distance in the upper navigable region of the Dnieper, sandbanks are experienced, and regularization and dredging will have to be extensively done; for the next 270 miles the principal work would be the consolidation of the banks, and for the remaining 130 miles or so to the rapids there is granite. Then come the rapids, the river breaking through a granite ridge. The fall in a length of 40 miles is 90 feet. Timber is floated through here, but the river is impossible to navigation, except at spates. Recently projects have been proposed for the harnessing of the water power, and a commission was appointed to investigate the subject. The plan now proposed is to build at the foot of the rapids a dam of granite, with Portland cement mortar. The canal for the passage of ships—parallel to the river, but independent of the flow to the turbines—is to be 90 feet wide at the bottom, with a minimum radius of 1,500 feet; the depth of water is to be about 7 feet, and the canal is to be constructed of brickwork where it does not pass through the natural rock. The locks are to be made in pairs alongside each other, and to accommodate two vessels of 180 feet long, with a tug-boat of 120 feet long. The cost of the work in connection with the navigation is calculated to be between 27 and 28 million roubles. The water-power part of the undertaking is designed for three power-stations with vertical reaction turbines; the aggregate capacity throughout the whole year is calculated to be 100,000 horse-power. The current, of 5,000 volts, will be transmitted to the distributing stations in the vicinity of Ekaterinoslav and as far as Nishni Novgorod. A French syndicate is understood to have just made an offer to the Russian government to undertake the construction of the locks and hydro-electric power-stations on the Dnieper.

The funds for the improvement of the Dnieper River from the mouth at Kherson to the falls were voted some four years ago, and the work is probably completed by this time. The actual commencement of the work, through the medium of the State, of an undertaking comparable with that of the Siberian railway, will, if decided upon by the Duma, be of great advantage to the commerce and industries of Russia. Mr. A. Pabst, harbor engineer in Riga, who has for years been deeply interested in the movement, and on whose recent lecture on the subject our article is based, is to be congratulated on the progress of the propaganda work.

Proofs of the Sun's Variability*

It has been shown by experiments of the Smithsonian Astrophysical Observatory conducted simultaneously at Mount Wilson in California and Bassour in Algeria, in the years 1911 and 1912, that the values of the intensity of the solar radiation outside the atmosphere estimated by spectrobolometric observations at the two stations on the same days are, within the limits of error, identical. The measurements at the two stations agreed within an average deviation of about 1 per cent. It appeared, however, that the values of the solar constant of radiation obtained deviated over a range of nearly 10 per cent during the continuance of the expeditions. This deviation was observed at both stations, so that if high values were obtained in California, high values were obtained simultaneously in Algeria, and vice versa. Prof. Turner has computed from the observations the coefficient of correlation between the results at the two stations. He finds this coefficient to be 52 per cent plus or minus 7 per cent if all the observations are used. Rejecting three observations of extreme doubtfulness, the correlation coefficient rises to 60 per cent. This furnishes very strong evidence of the variability of the sun, which appears to be irregular in period and irregular in amplitude, but may range over a course of 5 per cent, or even more, within the lapse of a week.

Measurements of the solar constant of radiation have been conducted on Mount Wilson in California by the Smithsonian Astrophysical Observatory for about eight years, though, unfortunately, the observations have been confined to the months of summer and autumn, when the sky is favorable there for them. It is highly important that such work should be taken up at another station, or preferably at several other stations, where favorable conditions of the sky would be found in the other months of the year.

When the monthly mean values of the solar constant as obtained on Mount Wilson are compared with the sunspot numbers of Wolfer, it is found that increased sunspot numbers correspond with increased values of the solar radiation, and vice versa. Prof. Turner has computed the correlation coefficient for these two variables as depending upon fifty months of observations, and finds this coefficient to be 53 per cent plus or minus 7 per cent. Here also it is seen that a strong proof of the variability of the sun's radiation exists. It appears, therefore, that the sun, besides varying from day to day in the manner shown by the combined Algerian and Mount Wilson observations, also varies from year to year in connection with the march of the sunspot cycle.

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* From *Engineering*, London.

* C. G. Abbot, Director Astrophysical Observatory, Smithsonian Institution.

In September, 1913, a tower telescope, forming the image of the sun by the use of mirrors without lenses, and yielding an image of about 9 inches in diameter, was made ready in connection with the station of the Smithsonian Astrophysical Observatory on Mount Wilson. The image of the sun is caused to fall upon the slit of a spectrobolometer, which slit for this purpose is only about three eighths of an inch in height. By stopping the clock of the telescope, the solar image drifts centrally across the slit of the spectrobolometer, owing to the diurnal rotation of the earth. There is thus produced, by automatic registering of the indications of the bolometer, a curve of distribution of intensity along the diameter of the sun's disk. This curve takes the form of a letter U. The length of the straight sides of the U may be taken as representing the intensity of the solar radiation at the edge of the sun's disk, and the height of the U to the center of the curve may be taken as representing the intensity of the radiation at the center of the disk. Thus a contrast of the intensity of radiation along the diameter of the sun is made manifest. Observations were made on nearly 50 days of the year 1913 with this apparatus, and on each day the distribution of intensity at seven different wave-lengths of the spectrum between 3,700 angstroms and 10,000 angstroms was determined by making two curves at each wave length. On the same days the solar constant of radiation was determined at Mount Wilson.

Work with a similar object, but done in different ways, has been carried on by Vogel, Pickering, Langley, Very, Schwarzschild and Villager, and Abbot and Fowle. It is found, by comparison of the distribution curves obtained at Mount Wilson in 1913 with others obtained by Abbot and Fowle in 1907, that a change of form of the distribution curve has occurred between these epochs.

The contrast of brightness between the center and edge of the sun in the year 1907 was greater than the contrast found in the year 1913. This is verified at all wave-lengths; but the change of contrast is greater for short wave-lengths than for longer ones.

It further appears, by comparison of results of one day with another in the year 1913, that a change of contrast is going on all the time, similar in irregularity of period and amplitude with the variation of the sun's total radiation which was found by comparison of Mount Wilson and Bassour observations. When the daily values of the solar constant of radiation obtained in 1913 are compared with the distribution of brightness along the sun's diameter, it is seen that a close correspondence of variation occurs between the two. This daily variation is of such a nature that when the solar constant values increase, the constant of brightness between the center and edge of the sun diminishes. The result is contrary to that which was indicated by a few observations of Abbot and Fowle in the year 1908. It is believed, on further examination, that the results of Abbot and Fowle in 1908 were made erroneous by certain defects in the measurements of the solar constant of radiation on two or three days. The new results come from nearly fifty days of observation, and are quite definite in showing the connections between the variation of the radiation of the sun and the variation of brightness along the sun's diameter.

It appears, however, that the correlation between solar constant values and contrast values between the years 1907 and 1913 is contrary in its sign to the correlation between these variables exhibited by the daily march of values for the year 1913. This may point to a greater complexity of the solar problem than was at first indicated by the results of Abbot and Fowle. It may be that the march of the sunspot period attends an influence in one direction, while the march of short-period fluctuations of the solar radiation from day to day attends a change of contrast in the other direction.

European Railways in War Time*

American railway officers who have been inclined toward discouragement on account of the poor business conditions and the resulting effect on traffic and earnings which have prevailed in this country for several months, and which still exist, with considerable uncertainty as to the future, should be able to extract a grain of comfort from observation of the far worse plight of the roads in Europe. On the continent of Europe, railways in the territory affected by war operations have been required practically to suspend business except for the transportation of troops, and a great deal of their property has been destroyed or damaged, while the lines that are not directly affected by military operations are suffering from the loss of traffic because business is at a standstill. In Great Britain, where the railways are all owned by private companies, the government immediately on the declaration of war with Germany on August 4th, issued an order assuming control of the railways. For the time being, the railways practically cease to exist as individual commercial undertakings and are merely parts of a great national system.

The announcement of this step made by the British War office was as follows:

"An order in council has been made under section 16 of the Regulation of the Forces act of 1871, declaring that it is expedient that the government should have control over the railways in Great Britain. This control will be exercised through an executive committee composed of general managers of railways, which has been formed for some time, and has prepared plans with a view to facilitating the working of these provisions of the act.

"Although the railway facilities, for other than naval and military purposes, may for a time be somewhat restricted, the effect of the use of the powers under this act will be to co-ordinate the demands on the railways of the civil community with those necessary to meet the special requirements of the naval and military authorities.

"More normal conditions will in due course be restored, and it is hoped that the public will recognize the necessity for the special conditions, and will, in the general interest, accommodate themselves to the inconvenience involved."

The railway executive committee is composed of the general managers of ten of the leading railways in Great Britain, with the president of the Board of Trade as official chairman, and H. A. Walker, general manager of the London & South Western, as acting chairman. An American, H. W. Thornton, general manager of the Great Eastern, and formerly general superintendent of the Long Island, was not numbered among those chosen at first, but the committee had been in charge of affairs only two days when he was asked to become a temporary member, which he did.

This committee, through Mr. Walker, immediately issued a notice to the public explaining the situation, and stating that the control of the railways had been taken over by the government for the purpose of insuring that the locomotives, rolling stock and staff could be used as one complete unit in the best interests of the state, for the movement of troops, stores, and food supplies. "The necessity for this action must at once become apparent," the announcement said, "when it is realized that certain ports through which the bulk of our food supplies enters this country may be closed for the purpose of such food supplies and in that event the rolling stock, locomotives, etc., may have to be diverted to other lines for the purpose of serving other ports. The staff on each railway will remain under the same control as heretofore, and will receive their instructions through the same channels as in the past."

The announcement also stated that in order to give due effect to the instructions received from the War Office and the Admiralty for the movement of troops, etc., it might be necessary to discontinue, at short notice, a portion of the advertised service or to close certain of the lines against ordinary traffic, and that, under such circumstances, no responsibility could be accepted for any delay or loss that might arise.

The act under which control of the railways was taken by the government provides that when the Crown, by an order in council, declares that an emergency has arisen in which it is expedient for the public service that the government shall have control over the railroads or any of them, the secretary of state, by warrants, may empower any person or persons named to take possession of any railroad in the United Kingdom and of its plant or of any part thereof, or may take possession of the plant without taking possession of the railroad itself and use it for government service in such manner as the secretary of state may direct. Any such warrant is to remain in force for one week only, but may be renewed from week to week as long as, in the opinion of the secretary of state, the emergency continues. The act also provides for such full compensation for any loss or injury sustained by the railway companies by the exercise of this power as may be agreed upon between the secretary of state and the railways, and provides for arbitration in the case of difference; and that while the railways are in the hands of the government, all contracts for the operation and maintenance of the road shall be enforceable by or against the government.

The arrangement necessary for moving troops, horses and materials by rail for mobilization have been constantly under consideration by the military authorities, and the railways have naturally been regarded as an important factor in any mobilization scheme. There is a war railway council and a railway staff corps attached to the Royal Engineers, and there have been various meetings at the Board of Trade to discuss methods for obtaining the maximum efficiency of the railways. Immediately following the taking possession of the railways by the government, the London & South Western gave notice that, in consequence of the requirements in connection with the movement of the forces, it was not practicable to continue the whole of the passenger train service as advertised, and that it would be necessary to reduce and alter this service from August 5th until further notice. The notice stated that full particulars of the suspension and alteration would be issued, and the company also announced that it would be unable to guarantee the running or punctuality of trains, and could not be responsible for any delay, loss or damage which might occur in passenger train service. Similar notices of modified passenger train service were issued by other leading English and Irish railway companies, several of which announced that their ordinary passenger and goods train service would be subject to material alteration and discontinuance without further notice.

The publication of weekly traffic returns of the railways was also discontinued, as during the continuance of the war the railways will be operated almost as a single system, the government compensating the companies for any loss or injury in paying for the movement of troops and stores after the railways are restored to normal conditions. As the sums to be received from the government cannot be dealt with in weekly installments, the publication of these reports would, under the circumstances, be futile. With the business of the country disorganized on account of the obstacles to export and import traffic, the business of the railways would, of course, have been vitally affected even without the necessity for the use of their lines for military purposes.

With the practical cessation of European imports and exports and the general interruption of all kinds of business, the merchandise and general traffic has been heavily reduced, and the pleasure and ordinary passenger travel reduced to a minimum. Operating expenses will also naturally be affected by the rise in the prices of materials and in other ways. The declaration of dividends was postponed by several railways, pending the outcome of events.

The *Railway News*, of London, in its issue of August 8th, published an estimate that over 20,000 railway employees had left their employment in obedience to mobilization orders, their places being filled by promoting men of lower grades or by taking on new men for the less skilled occupations. The companies announced that so far as possible they would keep places open for the men who return to civil life when the war ends. At the time of the South African war, the railways not only made arrangements for keeping places open, but also for providing for those dependent upon the men killed or incapacitated during their military service. Similar arrangements are being made now.

The British railways have never yet been put to a complete test as to their ability in the matter of handling such a volume of traffic as would be necessitated in the transportation of an army to resist invasion, but they have often been called upon to handle large numbers of troops, horses and military equipment for maneuvers and royal reviews, frequently at times when their capacity was being subjected to a far greater strain by the handling of holiday passenger traffic.

The British railways are admirably adapted to the handling of troops in large numbers. Among the factors which are considered advantageous are the duplication of lines and the proximity of stations to each other. As the stations are rarely more than three or four miles apart, not all of the trains need go to the same station. Thus if 12 trains are required for the district served by stations *A*, *B* and *C*, the first, fourth, seventh and tenth trains could go to *A*, the second, fifth, eighth and eleventh to *B*, and the remainder to *C*. Should the trains run at 10 minute intervals, there would be half an hour to load or unload the first at *A* before the next train was due. Moreover, nearly all of the lines are double track and two trains may therefore, in emergency, be run in the same direction at the same time. Other advantages are found in the complete installation of block signals, telephones, speaking instruments and other signals.

As to the continental railways they are largely owned by the governments, and a great many lines have been built with reference to their possible use in war time; and naturally the transportation of military forces has been their first consideration. Germany's arrangements for mobilization by railway have been unusually complete. A war time-table, revised as occasion demanded, has always been in the possession of railway officers throughout the country, capable of being put into force at the shortest notice. All railways are administered by the military authorities in time of war, irrespective of whether the railways are state or company owned.

The Russian railways have a different gage from the other European lines and this difference has been maintained for strategic reasons. Short strategic lines built by Germany on the French and Belgian frontiers naturally have been of the greatest importance, and in addition most of the main lines are so located as to have the greatest efficiency for military purposes.

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* *Railway Age Gazette.*

Plant Autographs and Their Revelations*

How Plants Are Compelled to Write the Story of Their Feelings and Sensations

In answering the question whether there is a fundamental unity in the response of plant and animal, we have first to find out whether sensitiveness is characteristic of only a few plants or whether all plants and every organ of every plant is sensitive. Then we have to devise apparatus by which visible or invisible reactions are detected and recorded. Having succeeded in this, we have next to survey the characteristic reactions in the animal, and observe whether phenomena corresponding to these may also be discovered in the plant.

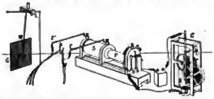

Fig. 1.—Diagrammatic representation of automatic plant recorder.

Petiole of Mimosa, attached by thread to one arm of level *L*; writing index *W* traces on smoked glass plate *G* the responsive fall and recovery of leaf. *P*, primary; *S*, secondary of induction coil. Exciting induction shock passes through the plant by electrodes *E*, *E'*. *C*, clockwork for regulating duration of tetanizing shock. Primary circuit of coil completed by plunging rod *R* dipping into cup of mercury, *M*.

Thus, when an animal is struck by a blow, it does not respond at once. A certain short interval elapses between the incidence of the blow and the beginning of the reply. This lost time is known as the latent period. In the plant is there any definite period which elapses between the incident blow and the responsive twitch? Does the latent period undergo any variation as in the animal, with external conditions? Is it possible to make the plant itself write down this excessively minute time-interval?

Next, is the plant excited by various irritants which also excite the animal? If so, at what rate does the excitatory impulse travel in the plant? In what favorable circumstances is this rate of transmission enhanced, and in what other circumstances is it retarded or arrested? Is it possible to make the plant itself record this rate and its variation? Is there any resemblance between the excitatory impulse in the plant and the nervous impulse in the animal?

The characteristic effects of various drugs are well known in the case of the animal. Is the plant similarly susceptible to their action? Will the effect of poison change with the dose? Is it possible to counteract the effect of one by means of another?

In the animal there are certain automatically pulsating tissues like the heart. Are there any such spontaneously beating tissues in the plant? If so, are the pulsations in the animal and the plant affected by external conditions in a similar manner? What is the real meaning of spontaneity?

Growth furnishes us with another example of automatism. The rate of growth in a plant is far below anything we can directly perceive. How, then, is this growth to be magnified so as to be rendered instantly measurable? What are the variations in this infinitesimal growth under external stimulus of light and shock of electric current? What changes are induced by giving or withholding food? What are the conditions which stimulate or retard growth?

And, lastly, when, by the blow of death, life itself is finally extinguished, will it be possible to detect the critical moment? And does the plant then exert itself to make one overwhelming reply, after which response ceases altogether?

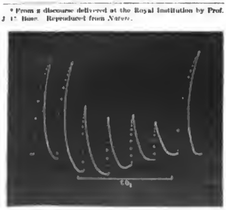

Fig. 4.—Effect of carbonic acid gas.

PLANT-SCRIPT.

The plant is acted upon by storm and sunshine, warmth of summer and frost of winter, drought and rain. What coercion do they exercise upon it? What subtle impress do they leave behind? These internal changes are entirely beyond our visual scrutiny. The possibility of these being revealed to us lies in the detection and record of the actual response of the organism to a questioning shock. By the invention of different types of recorders, I have succeeded in making the plant itself write an answering script to a testing stimulus. Thus the plant attached to the recording apparatus is automatically excited by a stimulus absolutely constant. In answer to this it makes its own responsive records, goes through its period of recovery and embarks on the same cycle over again, without assistance at any point from the observer (Fig. 1).

THE RESONANT RECORDER.

In obtaining the actual record of responsive movements in plants we encounter many serious difficulties. In the case of muscle-contraction, the pull exerted is considerable and the friction offered by the recording surface constitutes no essential difficulty. In the case of plants, however, the pull exerted by the motile organ is relatively feeble, and in the movement of the very small leaflets of *Desmodium gyrans* or the telegraph plant, for instance, a weight so small as four-hundredths of a gramme is enough to arrest the pulsation of the leaflets. Even in the leaf of Mimosa the friction offered is enough to introduce serious errors into the amplitude and time-relations of the curve. This error could not be removed as long as the writer remained in continuous contact with the writing surface. I was finally able to overcome the difficulty by making an intermittent, instead of a continuous contact. The possibility of this lay in rendering the writer tremulous, this being accomplished by an invention depending on the phenomenon of resonance. The principle of my resonant recorder depends on sympathetic vibration. If the strings of two violins are exactly tuned, then a note sounded on one will cause the other to vibrate in sympathy. We may likewise tune the vibrating writer *V*, with a reed *C* (Fig. 2). Suppose the reed and the writer are both tuned to vibrate a hundred times per second. When the reed is sounded, the writer will also begin to vibrate in sympathy. In consequence of this, the writer will no longer remain in continuous contact with the recording plate, but will deliver a succession of taps a hundred times in a second. The record will therefore consist of series of dots, the distance between one dot and the next representing one-hundredth part of a second. With other recorders it is possible to measure still shorter intervals. It will now be understood how, by the device of the resonant recorder, we not only get rid of the error due to friction, but make the record itself measure time as short as may be desired. The extraordinary delicacy of this instrument will be understood when by its means it is possible to record a time-interval as short as the thousandth part of the duration of a single beat of the heart. In finding the best mode of applying quantitative stimulus to the plant an interesting discovery was made about the extreme sensitiveness of certain plants to the stimulus of electric current. The most sensitive organ by which an electric current can be detected is our tongue. An average European, according to Laserstein, can perceive by his tongue a current as feeble as 6.4 microamperes—a microampere being one-millionth part of the unit of current. This value might be subject to certain variation, depending on racial characteristics. One might expect that the tongue of the Celt would be far more excitable than that of the stolid Anglo-Saxon. In any case, the superiority of man has to be established on foundations more secure than sensibility; for the plant Biophytum, I find, is eight times more sensitive to an electrical current than a human being. With regard to the stimulus of induction shock, Mimosa is ten times as sensitive.

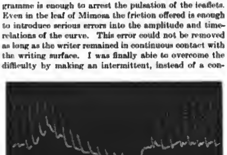

Fig. 3.—Hourly record for twenty-four hours, exhibiting diurnal variation of excitability (spring specimen).

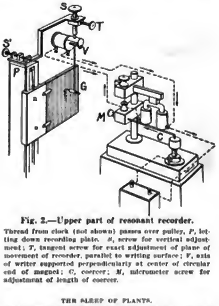

Fig. 2.—Upper part of resonant recorder.

Thread from clock (not shown) passes over pulley, *P*, letting down recording plate. *S*, screw for vertical adjustment; *T*, tangent screw for exact adjustment of plane of movement of recorder, parallel to writing surface; *V*, axis of writer supported perpendicularly at center of circular end of magnet; *C*, coercer; *M*, micrometer screw for adjustment of length of coercer.

THE SLEEP OF PLANTS.

In studying the effect of a given change in the external condition, an assumption has to be made that, during the time of experiment, there has been no spontaneous variation of excitability. Is the plant equally excitable throughout day and night? If not, is there any particular period at which the excitability remains uniform? Is there again a different time during which the plant loses its sensibility—going, as it were, to sleep? On these points no definite information has been available. The fanciful name of sleep is often given to the closure of leaflets of certain plants during darkness. These movements are brought about by variation of turgor, and have nothing whatever to do with true sleep; for similar closure of leaflets takes place under the precisely opposite condition of strong light.

In order to find out whether Mimosa exhibits diurnal variations of sensibility, I made it record its answer to uniform questioning shocks, repeated every hour of the day or night. The amplitude of the answering twitch gave a measure of the "wakefulness" of the plant during twenty-four hours. The results obtained were quite unexpected. The plant is found to keep up very late, and fall asleep only at the early hours of the morning. It makes up for its late hours by gradually waking up by noon (Fig. 3). It then remains in a condition of uniform sensibility all the afternoon. This period of uniformity is chosen for investigations on the effect of changed external conditions on excitability.

EFFECT OF AIR, FOOD, AND DRUGS.

The plant is intensely susceptible to the impurities present in the air. The vitiated air of the town has a very depressing effect. According to popular science, what is death to the animal is supposed to be life for the plant; for does it not flourish in the deadly atmosphere of carbonic acid gas? The record (Fig. 4) shows that, instead of flourishing, the plant gets suffocated just like a human being. Note the gasp of relief when fresh air is introduced. Only in the presence of sunlight is this effect

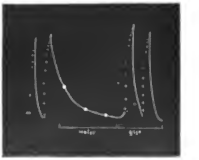

Fig. 5.—Abolition of motile excitability by excessive absorption of water, and subsequent restoration by withdrawal of excess.

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* From a discourse delivered at the Royal Institution by Prof. J. C. Bose. Reproduced from *Nature*.

modified by photosynthesis. In contrast to the effect of carbonic acid, ozone renders the plant highly excitable. Sulphureted hydrogen, even in small quantities, is fatal to the plant. Chloroform acts as a strong narcotic, inducing a rapid abolition of excitability. The ludicrously unsteady gait of the response of plants under alcohol could be effectively exploited in a temperance lecture! The record (Fig. 5) is in the nature of an anticlimax, where the plant has drunk (pure water!) not wisely but too well. The gorged plant is seen to have lost all power of movement. I was, however, able to restore the plant to normal condition by extracting the excess of liquid by application of glycerin.

It may be urged that the various reactions of irritability may hold good only in the case of the particular plant Mimosa, and that the majority of plants were quite insensitive. I have, however, been able to demonstrate in this very hall thirteen years ago, through my discovery of electric response in ordinary plants, that every plant and every organ of the plant is sensitive.[1] The difficult problem of finding the time taken by the plant to perceive and respond to a blow was solved by the employment of my resonant recorder, in which the writer was tuned to vibrate two hundred times a second. The successive dots are thus at intervals of 1/200 part of a second apart. In a particular experiment there are 15.2 intervals between the application of stimulus, represented by a vertical line, and the initiation of response (Fig. 6). The latent period, therefore, in this case is 0.076 of a second. The reaction time of the plant becomes very sluggish under fatigue.

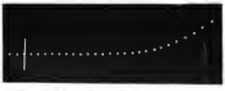
Fig. 6.—Record showing the latent period of Mimosa. The recorder vibrates 200 times per second. The time-interval between successive dots is here 0.005 second.

EXCITATORY IMPULSE IN MIMOSA.

I next take up the question of transmission of excitation in plants. It has hitherto been supposed in Mimosa the impulse caused by irritation is merely hydro-mechanical, and quite different from the nervous impulse in the animal. According to this hydro-mechanical theory, the application of mechanical stimulus is supposed to squeeze the tissue, in consequence of which the water forced out delivers a mechanical blow to the contractile organ of the plant. Such hydro-mechanical transmission is in no way affected by any physiological agencies as warmth or cold, or the application of various anæsthetics or poisons.

In strong contrast to this is the transmission of nervous impulse, which is a phenomenon of passage of protoplasmic disturbance from point to point. Here under favorable physiological conditions, such as warmth, excitatory impulse is transmitted with a quicker speed. There are certain agents again which paralyze the conducting tissue for the time being, causing a temporary arrest of the impulse. Such agents are known as anæsthetics. There may again be poisonous drugs which permanently abolish the conducting power. The nature of an impulse may thus be discriminated by several crucial tests. *The impulse must be physiological, or of a nervous character, if physiological changes affect the rate of conduction; absence of such effect, on the other hand, proves the mechanical character of the impulse.*

Of the various physiological tests, Pfeffer employed that of the narcotic drug. Chloroform applied on the *surface* of the stem of Mimosa failed to arrest the impulse. This result, at first sight, appears most convincing, and has been universally accepted as a disproof of the existence of nervous impulse in Mimosa. A little reflection will, however, show that under the particular conditions of the experiment, the conducting tissue in the interior could not have been affected by the external application of the narcotic, the task being, in fact, as difficult as narcotizing a nerve-trunk lying between muscles by the application of chloroform on the skin outside.

The question of nervous impulse in plants has thus to be attacked anew, and I have employed for this purpose twelve different methods. They all prove conclusively that the impulse in the plant is identical in character with that in the animal. Of these I shall give a short account of two different modes of investigation. It is obvious that the transmitted impulse in Mimosa must be of an excitatory, or nervous character:

(1) If it can be shown that physiological changes induce appropriate variation in the velocity of transmission of the impulse.

(2) If the impulse in the plant can be arrested by different physiological blocks by which nervous impulse in the animal is arrested.

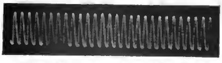
Fig. 9.—Record of automatic pulsations in Desmodium gyrans.

For the last two investigations the research resolves itself into the accurate measurement of the speed with which an impulse in the plant is transmitted, and the variation of that speed under changed conditions. A portion of the tissue at *C* may, for example, be subjected to the action of cold, or of a poisonous drug (Fig. 7). In order to find the speed of normal transmission, we apply an instantaneous stimulus, say, of an electric shock, at *B*, near the pulvinus. A short interval, the latent period, will elapse between the application of stimulus and the beginning of responsive movement. After the determination of the latent period, we apply stimulus once more at *A*, and observe the time which elapses between the application of stimulus and the response. The difference between the two periods gives us the time required for the excitation to travel from the point of application of stimulus at *A*, to the responding organ at *B*; hence we obtain the speed of impulse in the plant. The experiment is repeated once more, after the application of a given agent at *C*. If the speed undergoes any variation, it must be due to the action of the given agent.

DETERMINATION OF SPEED OF EXCITATORY IMPULSE IN PLANTS.[2]

As relatively long intervals have to be measured in the determination of velocity, the recorder has its frequency adjusted to ten vibrations per second; hence the space between successive dots represents an interval of one-tenth of a second. In Fig. 8 is given a record for determining the velocity of transmission. The two lower figures give practically identical results of successive experiments when stimulus was applied at a distance of 30 millimeters. The uppermost is the record for direct stimulation. From these it is seen that the interval between stimulus and response is 1.6 seconds, and that the latent period is 0.1 second. Hence the true time for the excitation to travel through a distance of 30 millimeters is 1.5 seconds, the velocity being 20 millimeters per second.

Fig. 8.—Determination of velocity of transmission in Mimosa.

The two lower records are to response to stimulus applied at a distance of 30 millimeters; the upper record exhibits latent period in response to direct stimulus applied on the pulvinus. Successive dots to this and following records are of intervals of one tenth part of a second.

The velocity of nervous impulse in the plant is slower than those of higher, but quicker than those of lower animals. The speed of the impulse is, however, subject to variation under different conditions. One significant result that came out was that while a plant carefully protected under glass from outside blows looked sleek and flourishing, yet as a complete and perfect organism it proved to be a failure. Its conducting power was found atrophied or paralyzed. But when a succession of blows rained on this effete and bloated specimen, the stimulus canalized its own path of conduction, and it became more alert and responsive, and its nervous impulses became very much quickened.

EFFECT ON PHYSIOLOGICAL AGENCIES ON VELOCITY.

A decisive experiment to discriminate between the theories of mechanical and nervous transmissions consists in the determination of the effect of temperature on the speed of transmission. Temperature has no effect on mechanical propagation, whereas a moderate variation of it profoundly affects the rate of nervous transmission. In the case of the plant, I find that the velocity is doubled by rise of temperature through 9 deg. Cent. When a portion of conducting petiole is subjected to cold the speed of conduction is retarded. Excessive cold temporarily abolishes the conducting power.

As an after-effect of the application of intense cold, the conducting power remains paralyzed for a considerable length of time. It is a very interesting and suggestive fact that I have been able to restore the conducting power quickly by subjecting the paralyzed portion of the plant to a measured and moderate dose of electric shock.

Various physiological blocks can be made to inhibit the excitatory impulse in the plant, precisely as in the case of animal nerve. The nervous impulse in plants may thus be arrested by electrotonic block or by the action of poisons. By applying solution of potassium cyanide I have been able to abolish the conducting power in the plant in a time as short as five minutes. This investigation on the simplest type of plant-nerve is expected to cast a flood of light on the very obscure phenomenon of nervous impulse in general, and the causes operative in bringing about the degeneration of the normal function of the nerve.

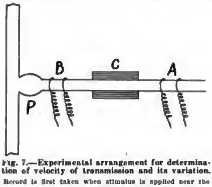

Fig. 7.—Experimental arrangement for determination of velocity of transmission and its variation.

Record is first taken when stimulus is applied near the pulvinus at *B* (latent period) and that at a distant point on the leaf stalk at *A*. Difference of two gives time for transmission from *A* to *B*. The band of cloth, *C*, is for local application of warmth, cold, anæsthetics, and poisons.

SPONTANEOUS PULSATION.

In certain animal tissues, a very curious phenomenon is observed. In man and other animals, there are tissues which beat, as we say, spontaneously. So long as life lasts, so long does the heart continue to pulsate. There is no effect without a cause. How then was it that these pulsations became spontaneous? To this query, no fully satisfactory answer has been forthcoming. We find, however, that similar spontaneous movements are also observable in plant tissues, as in *D. gyrans*, or the telegraph plant, the leaflets of which dance up and down. The characteristics of the automatic pulsations in the plant could not be determined on account of the apparent impossibility of obtaining a record. The leaflets are too minute and the pull exerted too feeble to overcome friction of the recording surface. This difficulty has been obviated by the device of my oscillating recorder (see pulse-record, Fig. 9). From the records thus obtained, I am enabled to say that the automatic movements of both plants and animals are guided by laws which are identical. Thus I find, as with the pulsating heart, so also with the pulsating leaflet, the rhythmic frequency is increased under the action of warmth, and lessened under cold, increased frequency being attended by diminution of amplitude, and *vice versa*. Under ether, there is a temporary arrest, revival being possible when the vapor is blown off (Fig. 10). More fatal is the effect of chloroform. The most extraordinary parallelism, however, lies in the fact that those poisons which arrest the beat of the heart in a particular way, arrest the plant-pulsation also in a corresponding manner, the arrest produced being either at systole or diastole, depending on the characteristic reaction of the poison. Taking advantage of the antagonistic reactions of specific poisons, I have been able to revive a poisoned leaflet by the application of another counteracting poison.

INSTANTANEOUS RECORD OF GROWTH.

As a further example of automatic activity we may take the phenomenon of growth. The rate of growth is so extremely slow that even the proverbial pace of the snail is two thousand times quicker! It would take an average plant two hundred years to cover the short distance of a mile. This extreme slowness is a serious drawback in the investigation on growth. For even with the existing magnifying growth-recorders it would take

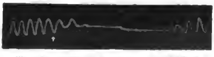
Fig. 10.—Arrest of pulsation of Desmodium under ether.

The arrow indicates the time of application.

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[1] Bose: Friday evening discourse, May 10th, 1901.

[2] For a more detailed account, consult:
Bose: "An Automatic Method for the Investigation of Velocity of Transmission of Excitation in Mimosa." Phil. Trans. Royal Society, Series B, vol. cciv.
Bose: "Plant Response." (Longmans, Green, 1906.)
Bose: "Researches on Irritability of Plants." (Longmans Green, 1913.)

many hours for the variation of growth to be recorded under a changed condition in the environment. The results thus obtained are subject to errors brought about by the variation of growth which takes place spontaneously in the course of a few hours. Growth can be assumed to remain constant only for a short time; on this account it is necessary to conclude an experiment in the course of a few minutes.

The difficulties have been overcome in my high magnification crescograph, which records the absolute rate of growth in a time so short as the single beat of the pendulum. The various magnifications available are a thousand or ten thousand times. For demonstration purposes, I have been able to secure a magnification of a million times. The infinitesimal growth thus becomes magnified so as to appear rushing forward as if in a race. The actual rate of growth and its variations under the action of drugs, of food-materials, of various electrical and other forms of stimuli, are thus recorded in the course of a few minutes. The great importance of this method of investigation in agriculture is sufficiently obvious.

THE PLANT'S RESPONSE TO THE SHOCK OF DEATH.

A time comes when, after an answer to a supreme shock, there is a sudden end of the plant's power to give any further response. This supreme shock is the shock of death. Even in this crisis there is no immediate change in the placid appearance of the plant. Drooping and withering are events that occur long after death itself. How does the plant, then, give this last answer? In man, at the critical moment, a spasm passes through the whole body, and similarly in the plant I find that a great contractile spasm takes place. This is accompanied by an electrical spasm also. In the script of the death-recorder the line, that up to this point was being drawn, becomes suddenly reversed and then ends. This is the last answer of the plant to man's research.

The plant has thus been made to exhibit many of the activities which we have been accustomed to associate only with animal life. In one case, as in the other, stimulus of any kind will induce a responsive thrill. There are rhythmic tissues in the plant which, like those in the animal, go on throbbing ceaselessly. These spontaneous pulsations in one case, as in the other, are affected by various drugs in an identical manner. And in one case, as in the other, the tremor of excitation is transmitted with a definite and measured speed from point to point along conducting channels. The establishment of this similarity of responsive actions in the plant and animal will be found of the highest significance; for we now realize that it is by the study of the simpler phenomena of irritability in the vegetal organisms that we may expect to elucidate the more complex physiological reactions of the animal.

The Stability of Aeroplanes*

The Various Intricate Problems of Balance

By Orville Wright, B.S., LL.D.

A FLYING machine must be balanced in three directions: about an axis fore and aft in its line of motion, about an axis extending in a lateral direction from tip to tip of the wings, and about a vertical axis. The balance about the lateral axis is referred to as fore-and-aft or longitudinal equilibrium; that about the fore-and-aft axis as lateral equilibrium, and that about the vertical axis is generally referred to as steering, although its most important function is that of lateral equilibrium.

If the center of support of an aeroplane surface would remain fixed at one point, as is practically the case in marine vessels and in balloons and airships, equilibrium would be a simple matter. But the location of the center of pressure on an aeroplane surface changes with every change in the angle at which the air strikes the surface. At an angle of 90 degrees it is located approximately at the center of the surface. As the angle becomes less, the center of pressure moves forward. On plane surfaces it continues to move forward as the angle decreases until it finally reaches the front edge. But on cambered surfaces the movement is not continuous. After a certain critical angle of incidence is reached, which angle depends upon the particular form of the surface, the center of pressure moves backward with further decrease in angle until it arrives very close to the rear edge. At angles ordinarily used in flying, angles of 3 degrees to 12 degrees, the travel of the center of pressure is in this retrograde movement and is located, according to the angle of incidence, at points between 30 per cent and 50 per cent back of the front edge of the surface. The location of the center of pressure on any given surface is definitely fixed by the angle of incidence at which the surface is exposed to the air.

The placing of the center of gravity of the machine below its center of support appears, at first glance, to be a solution of the problem of equilibrium. This is the method used in maintaining equilibrium in marine vessels and in balloons and airships, but in flying machines it has the opposite of the desired effect. If a flying machine consisting of a supporting surface, without elevator or other means of balancing, were descending vertically as a parachute, the center of gravity vertically beneath the center of support would maintain its equilibrium. But as soon as the machine begins to move forward the center of pressure, instead of remaining at the center of the surfaces, as was the case when descending vertically, moves toward that edge of the surface which is in advance. The center of gravity being located at the center of the surface and the center of pressure in advance of the center of the surface, a turning moment is created which tends to lift the front of the machine, thus exposing the surfaces at a larger angle of incidence and at the same time to a greater resistance to forward movement. The momentum of the machine, acting through its center of gravity below the center of forward resistance, combines with the forward center of pressure in causing the surface to be rotated about its lateral axis. The machine will take an upward course until it finally comes to a standstill. The rear edge of the surface will now be below that of the front edge and the machine will begin to slide backward. The center of pressure immediately reverses and travels toward the rear edge of the surface, which now in the backward movement has become the front edge. The center of gravity again being back of the center of pressure, the advancing edge of the surface will be lifted as before, and the pendulum effect of the low weight will be repeated. A flying machine with a low center of gravity, without rudders or other means to maintain its equilibrium, will oscillate back and forth in this manner until it finally falls to the ground.

It will have been observed from the foregoing that the equilibrium in the horizontal plane was disturbed by two turning moments acting about the lateral horizontal axis of the machine; one produced by the force of gravity and the lift of the surface acting in different vertical lines, and the other by the center of momentum and the center of resistance acting in different horizontal lines.

It is evident that a low center of gravity is a disturbing instead of a correcting agent. The ideal form of flying machine would be one in which the center of gravity lies in the line of the center of resistance to forward movement and in the line of thrust. In practice this is not always feasible. Flying machines must be built to land safely as well as to fly. A high center of gravity tends to cause a machine to roll over in landing. A compromise is therefore adopted. The center of gravity is kept high enough to be but a slight disturbing factor in flight and at the same time not so high as to interfere in making safe landings.

The three forces acting on an aeroplane in the direction of its line of motion are the thrust of the propellers, the momentum or inertia of its weight, and the resistance of the machine to forward travel. If traveling in any other than a horizontal course, a component of gravity in the line of motion will have to be reckoned with. When these forces are exerted in the same line, with the centers of thrust and momentum acting in the opposite direction to that of the center of resistance, a variation in the quantity of any one, or of all, of these forces will not in itself have a disturbing effect on the equilibrium about the lateral horizontal axis. But these forces in the ordinary flying machine do not act in the same line. Usually the center of thrust is high in order to give proper clearance between the propellers and the ground; the center of gravity is low to enable the machine to land without danger of being overturned; and the center of resistance is usually between the centers of thrust and gravity. When a flying machine is traveling at uniform speed the propelling forces exactly equal the resisting forces. In case the thrust of the propellers is diminished by throttling the motor, the momentum of the machine acting below the center of resistance carries the lower part of the machine along faster than the upper part, and the surfaces thus will be turned upward, producing a greater angle and a greater resistance. The same effect is produced if the machine be suddenly struck by a gust of wind of higher velocity from in front. The thrust of its propellers will be temporarily slightly decreased, the resistance due to the greater wind pressure will be increased, and the momentum of the machine (the center of gravity being low) will in this case also turn the surfaces upward to a larger angle. While these variations in the forces acting in the horizontal line have of themselves a certain amount of disturbing effect, yet it is from the changes of incidence which they introduce that one encounters the greatest difficulty in maintaining equilibrium.

The two principal methods used in preserving fore-and-aft equilibrium have been, first, the shifting of weight so as to keep the center of gravity in line with the changing center of lift; and, second, the utilization of auxiliary surfaces, known as elevators, to preserve the position of the center of pressure in line with a fixed center of gravity. The first method has been found impracticable on account of the impossibility of shifting large weights quickly enough. The second method is that used in most of the flying machines of to-day.

Flying machines of this latter type should have their auxiliary surfaces located as far as possible from the main bearing planes, because the greater the distance the greater is the leverage and consequently the smaller the amount of surface required. The auxiliary surfaces are usually placed either in front or in the rear of the main supporting surfaces, since they act with greater efficiency in these positions than when placed above or below.

With a view to high efficiency, no part of either the main surfaces or the auxiliary surfaces should be exposed on their upper sides in a way to create downward pressures. One pound of air pressure exerted downward costs as much in propelling power as two pounds of downward pressure produced by actual weight carried. This is due to the fact that the total pressure on an aeroplane is not vertical, but approximately normal to the plane of the surface. This pressure may be resolved into two forces, one acting in a line parallel with the direction of travel, and the other at right angles to the line of travel. One is termed "lift" and the other "drift." With a given aeroplane surface, the drift and lift for any given angle of incidence always bear a definite ratio to one another. This ratio varies from 1 to 12 to 1 to 1, according to the angle of incidence and the shape of the surface. On an average it is about 1 to 6, so that the thrust required of the propeller in the ordinary flying machine is approximately one sixth of the weight carried. When traveling on a horizontal course the lift is vertical and is exactly equal to the total weight of the machine and load. This load may be real weight, or it may be partly real weight and partly downward pressures exerted on parts of the surfaces. For every pound of weight carried, a thrust of approximately one sixth pound is required. If, however, instead of real weight a downward air pressure is exerted on some part of the machine, this downward pressure must be overcome by an equal upward pressure on some other part of the machine, to prevent the machine from descending. In this case the horizontal component of the one pound downward pressure will be about one sixth pound, and the horizontal component of the compensating upward pressure also will be about one sixth pound, making a total of one third pound required in thrust from the propellers, as compared with one sixth pound thrust required by one pound actual weight carried. It is, therefore, evident that the use of downward air pressures in maintaining equilibrium is exceedingly wasteful, and, as far as possible, should be avoided. In other words, when the equilibrium of an aeroplane has been disturbed, instead of using a downward air pressure to depress the elevated side an upward pressure should be utilized to elevate the low side. The cost in power is twice as great in one case as in the other.

The dynamically less efficient system of downward air pressures is used to some extent, however, on account of its adaptability in producing more or less inherently stable aeroplanes. An inherently stable aeroplane may be described as one in which equilibrium is maintained by an arrangement of surfaces, so that when a current of air strikes one part of the machine, creating a pressure that would tend to disturb the equilibrium, the same current striking another part creates a balancing pressure in the opposite direction. This compensating or correcting pressure is secured without the mechanical movement of any part of the machine.

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* Abstract of a paper presented at a stated meeting of the Franklin Institute held Wednesday, May 20th, 1914, when Dr. Wright received the Institute's Elliott Cresson Medal in recognition of the epoch-making work accomplished by him in establishing on a practical basis the science and art of aviation.

The first to propose the use of this system for the fore-and-aft control of aeroplanes was Penaud, a young French student, who did much experimenting with model aeroplanes in the 70's of the last century. His system is used only to a slight extent in the motor-driven aeroplanes of to-day, on account of its wastefulness of power and on account of its restriction of the maneuvering qualities of the machine.

Penaud's system consists of a main bearing surface and a horizontal auxiliary surface in the rear fixed at a negative angle in relation to the main surface. The center of gravity is placed in front of the center of the main surface. This produces a tendency to incline the machine downward in front, and to cause it to descend. In descending the aeroplane gains speed. The fixed surface in the rear, set at a negative angle, receives an increased pressure on its upper side as the speed increases. This downward pressure causes the rear of the machine to be depressed till the machine takes an upward course. The speed is lost in the upward course, the downward pressure on the tail is relieved, and the forward center of gravity turns the course again downward. While the inherently stable system will control a machine to some extent, it depends so much on variation in course and speed as to render it inadequate to meet fully the demands of a practical flying machine.

In order to secure greater dynamic efficiency and greater maneuvering ability, auxiliary surfaces mechanically operable are used in present flying machines instead of the practically fixed surfaces of the inherently stable type. These machines possess the means of quickly recovering balance without changing the direction of travel and of maneuvering with greater dexterity when required. On the other hand, they depend to a greater extent upon the skill of the operator in keeping the equilibrium. It may be taken as a rule that the greater the dynamic efficiency of the machine and the greater its possibilities in maneuvering, the greater the knowledge and skill required of the operator.

If the operator of a flying machine were able to "feel" exactly the angle at which his aeroplane meets the air, 90 per cent at least of all aeroplane accidents would be eliminated. It has been the lack of this ability that has resulted in so large a toll of human lives. Instruments have been produced which indicate closely the angle of incidence at which the machine is flying, but they are not in general use. Nor does the average flyer realize how exceedingly dangerous it is to be ignorant of this angle. Most of the flyers are aware that "stalling" is dangerous, but do not know when they really are "stalling."

A flying machine is in great danger when it is flying at its angle of maximum lift. A change either to a smaller or a larger angle results in a lesser lift. There is this important difference however, whether the angle be increased or decreased. While a smaller angle gives less lift, it also has less drift resistance, so that the machine is permitted to gain speed. On the other hand, the larger angle gives not only less lift but encounters a greater resistance, which causes the speed of the machine to be rapidly checked, so that there is a double loss of lift—that due to angle and that due to a lesser speed.

The maximum lift is obtained in most flying machines at some angle between 15 degrees and 20 degrees. If the machine be gliding from a height with the power of the motor throttled or entirely turned off, and the operator attempt to turn it to a level course, the speed of the machine will soon be reduced to the lowest at which it can support its load. If now this level course be held for even only a second or two, the speed and the lift will be so diminished that the machine will begin to fall rapidly.

The center of pressure on a cambered aeroplane surface at angles greater than 12 degrees to 15 degrees travels backward with increase of angle of incidence, so that when a machine approaches the "stalled" angles the main bearing surfaces are generally carrying practically all of the weight and the elevator practically none at all. Under these conditions the main surfaces fall more rapidly than does the rear elevator. The machine noses downward and plunges at an exceedingly steep angle toward the earth. This plunge would tend to bring the machine back to normal speed quickly were the machine flying at its usual angle of incidence. But at the large angles of incidence the drift is a large part of the total pressure on the surfaces, so that, although plunging steeply downward, speed is recovered but slowly. The more the operator tries to check the downward plunge by turning the elevator, the greater becomes the angle of incidence, and the greater the forward resistance. At ordinary stalled angles the machine must descend at an angle of about 25 degrees with reference to the horizontal in order to maintain its speed. If the speed be already below that necessary for support, a steeper angle of descent will be required, and considerable time may be consumed before supporting speed can be recovered. During all this time the machine is plunging downward. If the plunge begins at a height of less than two or three hundred feet, the machine is likely to strike the ground before the speed necessary to recover control is acquired.

The danger from "stalling" comes in the operator attempting to check the machine's downward plunge by turning the main bearing surfaces to still larger angles of incidence instead of pointing the machine downward, at a smaller angle of incidence, so that the speed can be recovered more quickly. It is safe to say that fully 90 per cent of the fatal accidents in flying are due to this cause. Most of the serious ones occur when, after long glides from considerable heights, with the power of the motor reduced, an attempt is made to bring the machine to a more level course several hundred feet in the air. The machine quickly loses its speed and becomes "stalled." All of us who have seen the novice make a "pancake" landing have seen the beginning of a case of "stalling" which might have been fatal had it taken place at a height of one or two hundred feet.

The greatest danger in flying comes from misjudging the angle of incidence. If a uniform angle of incidence were maintained, there would be no difficulty in fore-and-aft equilibrium. As has already been stated, for any given surface and any given angle of incidence the position of the center of pressure is fixed. Under these conditions, if the center of gravity were located to coincide with the center of pressure and a uniform angle of incidence maintained, the machine would always be in equilibrium.

It is in accordance with this principle that experiments the past year have brought about a considerable advance in the development of automatic stability. A small horizontal wind vane is so mounted on the machine as to ride edgewise to the wind when the machine is flying at the desired angle of incidence. In case the machine varies from the desired angle, the air will strike the vane on either its upper or lower side. The slightest movement of the vane in either direction brings into action a powerful mechanism for operating the controlling surfaces.

If the wind strikes the vane on the under side, as would be the case when the machine takes a larger angle of incidence, the elevator is turned to cause the machine to point downward in front till the normal angle is restored. If the air strike the vane from above, a smaller angle of incidence is indicated, and an opposite action on the elevator is produced. In this system no particular angle of the machine with the horizontal is maintained. It is the angle at which the air strikes the aeroplane surface that is important. If the vane is set at an angle of 5 degrees with the main supporting surfaces, and the machine is traveling on a level course, increasing the power of the motor will cause it to begin taking on more speed. But as the lifting effect of an aeroplane surface is the product of two factors—its speed and its angle of incidence—any increase in speed will produce a greater lift and cause the machine to rise. The machine will now be turned upward, with the surfaces meeting the air at an angle of 5 degrees. On the contrary, if the power of the motor be reduced or entirely turned off, the machine will immediately begin to decrease in speed, requiring a larger angle of incidence for support. But as soon as the angle begins to increase the air will strike the regulating vane on the underside and the elevator will be turned, pointing the machine downward till the component of gravity in the direction of travel becomes sufficient to maintain the normal speed. In this case the planes will be inclined downward with reference to the horizontal. It is evident that a machine controlled by regulating the angle of the machine with reference to the impinging air is not liable to the dangers of "stalling" already described.

Several other methods of maintaining fore-and-aft equilibrium automatically have been proposed. One utilizes the force of gravity acting on a pendulum or a tube of mercury; the other, the gyroscopic force of a rapidly revolving wheel. In both of these systems the angle of the machine is regulated with reference to the horizontal, or some other determined plane, instead of with the angle of the impinging air.

In the case just referred to, in which the power of the motor was suddenly turned off while traveling on a level course, with these systems, the planes would be maintained at their original angle with the horizontal without any regard to the angle of incidence. The machine would continue forward till, through the loss of momentum, its speed would become so reduced and its angle of incidence so great that it would be exposed to the dangers of diving.

The pendulum and mercury tube have other serious faults which render them useless for regulating fore-and-aft equilibrium. If the machine suddenly meet with a greater resistance to forward travel, either as a result of change in direction or of meeting a stronger gust of wind from in front, and its speed be ever so slightly checked, the pendulum will swing forward and instead of turning the machine downward, so as to maintain the normal speed, will cause the machine to be inclined upward in front and thus further increase its forward resistance.

The pendulum has proved itself an exceedingly useful device, however, in regulating the lateral stability of aeroplanes. In this case the effects of momentum and centrifugal force act on the pendulum in the proper direction to produce desired results.

I believe the day is near at hand when the flyer will be almost entirely relieved of the work of maintaining the equilibrium of his machine, and that his attention will be required only to keeping it on its proper course and in bringing it safely in contact with the ground when landing.

Problems Involved in the Cracking of Oils[*]

By Walter F. Rittman

Until recently it has been common to consider the so-called tar and petroleum oils as two separate and distinct materials. The present conceptions of organic chemistry however, avoid any sharp differentiations, such as those between the methane and benzine series. Instead, all hydrocarbons are considered together, and indicated as differing only in their hydrogen content. The latter classification is more fortunate because in the course of a dozen petroleums from different fields nearly all the various hydrocarbon series are represented. Many petroleums contain considerable percentages of the same constituents that are found in oil or water gas tar. In fact, it is possible to find two petroleums which differ as much in comparison as certain petroleums differ from so-called tar.

In dealing with the technical use of petroleum it can be said that we already know something about its end products; it at least appears that we know more about the end products than we do about the application of the most favorable conditions for obtaining maximum yields of the desired end products. It is known that valuable gasoline and illuminating gas can be obtained by cracking petroleum. What we want to know is how to increase the yields of gasoline or illuminating gas from a given amount of oil. It is questionable how much increase can be obtained by the perfection of the well known methods now in use. Radical increases can result only from the application of radical scientific principles.

In the production of petroleum end products practically all the variables of chemical reactions are involved. While this fact complicates the problem it makes the field of research more fertile and greatly enlarges its possibilities. We are dealing with chemistry involving both liquids and gases and with all the physical and chemical principles which apply to both of them. Mechanism of reaction, duration of temperature, contact surface, catalysis, temperature, pressure, and concentration conditions are all vitally important in the cracking of oils. They are all interesting, but in the time allotted me I shall deal with only the last three: temperature, pressure, and concentration.

The information that endothermic reactions work better at high temperatures while exothermic reactions work better at low temperatures is important, but this information does not become fully valuable until we regard as well the chemical equilibria between the various reacting constituents. The subject of chemical equilibrium is studied by practically all undergraduates, but its application to industrial problems, despite its value wherever applied, is still limited. There are very few experimental data dealing with equilibria between hydrocarbon vapors and gases; the principles affecting equilibria in fields which do not involve hydrocarbons are well known, however. There is no reason why these same principles should not be applied directly to hydrocarbons. Doing so leads to theoretical conclusions which suggest experimental research. Application of the principles indicates that the entire problem of cracking oils revolves about the equilibrium or kinetic conception of reaction.

It has been experimentally determined that when hydrogen iodide (HI) is heated there is a definite percentage of decomposition to H_2 and I_2, dependent upon the temperature of the system. Only at extremes of temperature do the equilibrium conditions carry the reaction completely in one direction. As the temperature is increased the percentage of decomposition increases. Equilibrium conditions prevail when the square of the partial pressure of HI, divided by the product of the partial pressures of H_2 and I_2, equals a constant.

The equilibrium relationships for hydrocarbons reactions have not been determined, but because of the validity of the equilibrium principles and the reversible nature of all chemical reactions investigated, we are reasonably safe in applying the same principles and reasonings in hydrocarbon reactions. The equilibrium considerations are important whatever end it is desired to reach, whether illuminating gas, gasoline, or some other products are the ones being sought. In some cases it will be found desirable to permit the reaction to reach an equilibrium at a relatively high temperature, whereas in other equally important hydrocarbon reactions the equilibrium of this high temperature would be destructive. In either case the equilibrium equation would serve as an indication of the degree of success that might be expected, as well as of the direction the reaction would take. Unfortunately practically none of the numerical values of the equilibrium constants for hydrocarbon reactions have been experimentally determined.

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[*] Journal of the Society of Chemical Industry.

The application of thermodynamic equilibria to hydrocarbons can be illustrated by one or two simple examples. Let us consider the following reactions and their constants (which are approximate):

	$K_{[illegible]}$	$K_{[illegible]}$
$C_2H_6 \rightleftarrows C_2H_4 + 2H$	0.0027	1.28
$3C_2H_2 \rightleftarrows C_6H_6$	$9 \times 10^{[illegible]}$	$1.2 \times 10^{[illegible]}$
$2CH_4 \rightleftarrows C_2H_4 + 2H_2$	0.000001	0.0004

Any number of others might be taken. Important mathematical expressions which give approximations for the values of these equilibrium constants for hydrocarbons can be found in such works on thermodynamics and physical chemistry.[1] As soon as more of them are known we shall have a better understanding of temperature conditions as related to other conditions in oil-cracking processes.

The application of different pressures in the sphere of reaction of the cracking process has been limited. Numerous patents and articles can be found indicating the use of increased pressure in the production of gasoline and illuminating gas. It has long been known that lubricating oils can be recovered more efficiently by distillation under partial vacuum. The distillation of aniline under diminished pressure through the use of steam is common laboratory practice. In such cases, however, the object of the process is not to crack an oil, but to avoid cracking it. So far, the effect of greatly diminished pressure on oil-cracking processes is practically uncovered. For a detailed consideration of this aspect of oil cracking see the articles on "Thermal Reactions in Carbureting Water Gas," by Whitaker and Rittman, *Jour. Ind. and Eng. Chem.*, vol. 6, pp. 383 and 472. To show the effect of varying the pressure when cracking an oil, consider the general reaction, $A \rightleftarrows 2B$ where equilibrium exists when $KA = B^2$. This equilibrium constant is identical with the ones referred to under temperature, and deals with the relative partial pressures at equilibrium under differing conditions of pressure. For numerical illustration assume the value of K to be equal to 1. From this one finds for partial pressures, when $A = 100$, $B = 10$, or when $A = 0.01$, $B = 0.1$. In the first case the partial pressure of A is ten times as great as that of B; in the second case the partial pressure of A is only one tenth as large as the partial pressure of B. In other words, by simply changing the total pressure on the system and keeping all other conditions constant, the ratio of A to B for the pressures shown has been divided by 100. This change can also be observed by plotting the parabola, $B^2 = KA$, where A and B are variables. From this it becomes evident that diminished pressure increases dissociation or decomposition to the gaseous state, whereas increased pressure decreases dissociation. The manufacture of gas under diminished pressure, as reported in the above mentioned articles, illustrates the former; the present methods of manufacturing gasoline from heavy oils by heating them under increased pressure illustrates the latter.

In dealing with the influence of concentration changes we are applying one of the common laws of physical chemistry. In the dissociation of HI by heat according to equation $2HI \rightleftarrows H_2 + I_2$, $K = \frac{P_{H_2}P_{I_2}}{P_{HI}^2}$ it is a well-known fact that less of the HI will dissociate in an atmosphere of H_2 or I_2 than in an atmosphere of nitrogen or any other inert gas. This can be observed from a mathematical consideration of equilibrium conditions, purely aside from the chemistry involved. Since the value of K does not change at any given temperature, if the partial pressure of H_2 is increased, the partial pressure of I_2 necessarily decreases unless the partial pressure of HI is increased simultaneously. Assume that the H_2 of the example cited were in excess to the extent that 50 per cent, instead of 10 per cent, of the resultant mixture were hydrogen; what, in this case, would be the partial pressures of HI and I_2, assuming the total pressure, to be equal to 1 atmosphere? $0.5 =$ partial pressure H_2, $x =$ partial pressure HI, $0.5 - x =$ partial pressure I_2.

$$K = \frac{P_{H_2}P_{I_2}}{P_{HI}^2} \qquad 0.0156 = \frac{(0.5)(0.5 - X)}{X^2}$$

Solving $X = 0.492$ HI, $0.5 - X = 0.008$ I_2, 0.5 H_2. 49.2 per cent HI, 0.8 per cent I_2, 50 per cent H_2. Thus, by having a large excess of hydrogen it is possible to eliminate, practically, the uncombined iodine. Or looking at the problem in another way, it is observed that almost none of the HI is dissociated, because of the excess of one of the end products of decomposition. In cracking oil hydrogen and methane are always among the end products.

Drawing an analogy one would expect that cracking petroleum in the presence of an end product, such as hydrogen, would lessen oil decomposition; in ordinary practice some oil decomposition is necessary to produce the hydrogen and other gases required by the equilibrium at that temperature. This decomposition might be avoided by the addition of the necessary hydrogen or other gases from an outside source. In experiments carried out in the laboratory it was found that when oil is cracked in the presence of an excess of hydrogen, not only does none of the hydrogen of the oil split off, but a considerable part of the added hydrogen actually enters into combination. This means that it is not necessary to generate new gaseous end products at the expense of more valuable hydrocarbons.

In conclusion, it appears that through the application of physical chemical principles to the cracking of oil, a better control of and greater flexibility in the resultant end products can be expected.

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[1] Nernst, Theoretical Chemistry (seventh edition). Jellinek Physikalische Chemie der Gasreaktionen nebst Thermochemie und Thermodynamik. Morgan, the Elements of Physical Chemistry.

Gun Deafness and Its Prevention

A SUBJECT of timely interest and importance and one that is closely allied to the subject of the industrial diseases in general is that of the injuries to the ear resulting from loud concussions. What may be regarded as one of the minor accidents of war is nevertheless, because of the large number of individuals concerned at the present time, one that cannot be ignored. Moreover, the aural injuries to which the soldier is exposed are no different from those of the boilermaker, of the structural iron worker, of the sportsman, and of those who are exposed to the shriek of the railway whistle when a train is passing through a tunnel or covered station. Jobson Horne, in the *Lancet*, August 15th, 1914, points out that the report of a piece of artillery, the concussion of an explosion, or the firing of a cannon close to the ear may exert its injurious effects upon the nerve terminals of the ear, may cause rupture of the drum membrane, and may even result in irremediable deafness. During the Russo-Japanese war, among the 1,791 men who were wounded in the naval engagements there were 116 cases of concussion of the labyrinth and rupture and congestion of the tympanic membrane, which cases represented 7 per cent of the wounded who survived. The injuries to the drum and to the nerve endings are due to the sudden condensation or rarefaction of the air in the external auditory meatus. As a rule one ear is more affected than the other. Politzer states that with the improvements in modern artillery ruptures of the drum membrane are now scarcely ever met with. This is attributed to the introduction of breech loaders and also to the fact that the serving party withdraws to a distance of about twelve paces with the exception of one man who attends to the firing, but who also stands at a considerable distance.

In naval warfare, however, the gunners cannot be protected in this manner. Experience has taught the gunner that by keeping the mouth open so as to equalize the air pressure on each side of the drum membrane the unpleasant consequences of concussion may be diminished. The toothpick that is chewed by naval officers while serving the guns partly fulfills this requirement, although a piece of rubber rolled between the teeth would be still better as a means of keeping the mouth partly open. The Japanese naval surgeons distributed pledgets of absorbent cotton to the entire crew with the instruction that the ears be plugged up during the firing of guns. In spite of this measure, possibly on account of its careless application in individual cases, many instances of deafness resulted. In 1911 the British Admiralty advised the use of an aural plug consisting of a mixture of plasticene and cotton-wool. Jobson Horne believes that an efficient aural plug should be close-fitting and impervious, and while reducing the intensity of sound should not prevent hearing; it should be easy to insert and easy to remove intact; it should be non-irritating; it should be inexpensive so that the same plug may not be used repeatedly; and, above all, it must be as nearly antiseptic as possible. Cotton-wool when inserted sufficiently tightly is not easily removed intact and does not long remain sterile when handled by men engaged in gun-firing. The ear plugs made of vulcanite rubber, or celluloid cannot be supplied to fit exactly the channel of the ear. They must be made of a substance that retains its shape without hardening or softening and remains ever plastic. A substance having the consistency of jeweler's wax may be produced and may be made to fulfill all the requirements of effectively plugging the ears and at the same time of preventing infection.—*Medical Record.*

A Novel Method of Fighting Spotted Fever is to be undertaken experimentally in the Bitterroot National Forest, Montana, by the Forest Service and the Public Health Service, in co-operation with local sheep growers. Spotted fever is believed to be disseminated by a species of tick, and the engorging of the female tick with blood is one of the essential features of reproduction. The host on which this engorging takes place is necessarily one of the larger mammals, and the commonest hosts appear to be domestic animals. As the spotted fever tick is so abundant in the Bitterroot Forest as to constitute a serious menace to man and beast, it is proposed to turn loose a flock of 2,500 sheep to graze in the forest, in the expectation that a great number of ticks will attach themselves to these animals. Then, from time to time, the sheep will be freed of ticks by dipping them in an insecticide solution. It is hoped that by this means ticks may be gradually banished from the forest.

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Nocturnal Warfare

The Automobile-Mounted Searchlights of the French Army

We are accustomed in these days to find the automobile put to a variety of practical uses. One of the recent developments of this kind is a traveling searchlight carried upon an automobile, and designed for military use in the French army. The general aspect of this new piece of military equipment is shown in Fig. 1 of our illustrations. The second figure shows some of the detail features of the arrangement for loading and unloading the truck for carrying the searchlight. The car can be propelled at some 19 miles an hour by an 18 horse-power motor burning gasoline, alcohol or oil, and capable of negotiating a 12 to 15 per cent grade. The fuel consumption is given as a little over 10 gallons per 100 miles. Both the automobile motor and that of the generator are of the De Dion Bouton type. The searchlight is a 7,000 candle-power electric arc lamp fitted with a 38-inch reflector. It is mounted upon a truck and can be taken from the car and set up at any suitable point within a distance of 328 feet, this being the length of the flexible current leads from the lamp to the car. The searchlight may, of course, be operated in its position on the car, if desired, but as a rule it is preferable to effect its manipulation from a distance, so as to avoid looking along the beam, and thus having a deep layer of brightly illuminated haze interposed between the eye and the object sighted, clouding the latter from view. In time of war it may also be an advantage to be able to place the searchlight in a comparatively exposed position, and yet to operate it from under cover. The device employed for this manipulation from a distance is very ingenious; without going into a full description it may here be said that its operation is based on the response of a tuning fork at the searchlight to a vibrating current sent out from a contact breaker tuned in unison with the tuning fork. There are as many tuning forks as there are different movements, each tuning fork responding to a specific contact breaker.

For field work, glass reflectors are undesirable owing

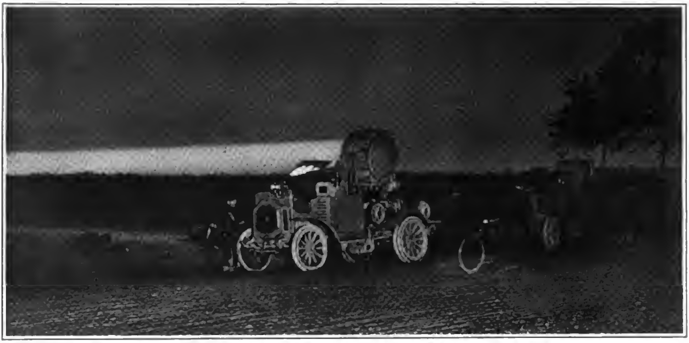

Fig. 1.—Automobile-mounted searchlight in use by the French army.

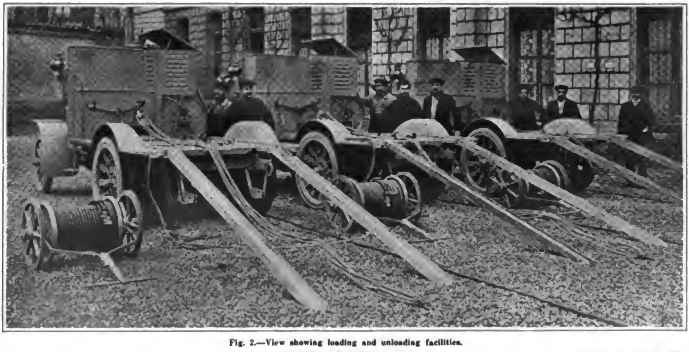

Fig. 2.—View showing loading and unloading facilities.

THE SEARCHLIGHT IN WAR

to their fragility. Silvered metal mirrors are unsatisfactory owing to the fact that they become tarnished under the influence of the electric arc. Of late, gilded mirrors have been used with success. The brightness of the electric arc may reach a figure as high as 250 candle-power per square millimeter. By the way of comparison it may be mentioned that lime light gives at most only 8 candle-power for the same area. The light comes almost entirely from the positive carbon, and the two electrodes are placed accordingly, so as to give the best effect. With a reflector of 60 inches diameter, good observations can be made at a distance of from two to three miles.

Train Signaling in France

In France, automatic train signaling has been adopted, or is being tested, on most of the principal lines, notably the Northern, Eastern, and Southern Railways, the Paris, Lyons and Mediterranean Railway, and the Orléans and State Railways.

Full descriptions of the various types of signaling apparatus adopted on each of the above lines were given a few days ago at the Paris meeting of the Institution of Mechanical Engineers by the engineers on the several lines. Most of the systems adopted are on the ramp principle, a metallic brush depending from the engine making electrical contact with a ramp placed between the rails and connected with the signal at the side of the line, thus giving a visible, and usually audible, warning in the driver's cab if the signal be at danger.

A typical warning and recording apparatus for signals at danger which is now adopted by the Paris, Lyons and Mediterranean Company on 140 express locomotives and on 258 miles of double track, with 316 signals fully equipped, was well described by Mr. L. Maréchal of the Paris, Lyons and Mediterranean Railway. Not only does the apparatus actuate a special whistle which warns the driver and stoker, but it gives on a speed-indicator roll a sign indicating which signal it was that stood at danger. The apparatus placed on the track comprises an insulated conductor, called a "crocodile" or ramp, placed as above described, and a switch worked by the signal and connected to the ramp and to the rails.

The apparatus on the engine consists of a brush which rubs on the ramp when the engine passes over it; a pneumatic horn giving the warning; an automatic device for unclutching and sending compressed air through the horn; an automatic device acting on the registering mechanism of the speed indicator; an electro-pneumatic relay, which provides the unclutching device at the horn and the registering apparatus with the compressed air required; a battery which provides the current for the electro-pneumatic relay; and, lastly, a compressed air receiver which feeds the apparatus.

This warning and registering system is thus based on the combined use of electricity and compressed air. It makes it necessary to use switches and ramps similar to those adopted on other railways where the system is entirely electrical. In this latter case electricity is the medium which brings about the unclutching of the apparatus during the very short time that the engine takes to pass over a ramp. This unclutching means a certain force being exercised, which, however weak, Mr. Maréchal claims to be not a negligible quantity, so that at high speeds failures might result.

In the Paris, Lyons and Mediterranean system electricity comes into play only to release the armature of the electromagnet of the relay, and to close a circuit on the engine itself, without doing any mechanical work. Through this local circuit of the electro-pneumatic relay (which is fed electrically from the battery on the engine and pneumatically from the receiver) being closed, the compressed air becomes the agent which definitely provides the mechanical power required for unclutching and reclutching.

On the Orléans Railway electrical train signaling is not used, the system preferred consisting of signals placed at a distance in advance of the danger point, the setting of which at "danger" is revealed by the explosion of two cartridges placed automatically on the track when the signal is set at "danger." If on account of atmospheric conditions or a moment's inattention a driver does not notice the signal by the side of the line, he will be warned of its presence at the moment he passes the post by the explosion of the two cartridges which the signal has guided on the rails when turned to "danger." The report produced by the explosion of the cartridges is so loud that it is impossible for it to be overlooked. This system, therefore, has the advantage not only of warning the driver himself of the presence of a signal, but also the officials, and even passengers on the train.—*The Daily Telegraph.*

Heredity—IV.

New Theories and Facts Relating to the History of Organic Beings

By Prof. William Bateson

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2021, Page 195, September 26, 1914

To all these great biological problems that modern society must sooner or later face there are many aspects besides the obvious ones. Infant mortality we are asked to lament without the slightest thought of what the world would be like if the majority of these infants were to survive. The decline in the birth-rate in countries already over-populated is often deplored, and we are told that a nation in which population is not rapidly increasing must be in a decline. The slightest acquaintance with biology, or even school-boy natural history, shows that this inference may be entirely wrong, and that before such a question can be decided in one way or the other, hosts of considerations must be taken into account. In normal stable conditions population is stationary. The laity never appreciates, what is so clear to a biologist, that the last century and a quarter, corresponding with the great rise in population, has been an altogether exceptional period. To our species this period has been what its early years in Australia were to the rabbit.

The exploitation of energy-capital of the earth in coal, development of the new countries, and the consequent pouring of food into Europe, the application of antiseptics, these are the things that have enabled the human population to increase. I do not doubt that if population were more evenly spread over the earth it might increase very much more; but the essential fact is that under any stable conditions a limit must be reached. A pair of wrens will bring off a dozen young every year, but each year you will find the same number of pairs in your garden. In England the limit beyond which, under present conditions of distribution, increase of population is a source of suffering rather than of happiness has been reached already. Younger communities living in territories largely vacant are very probably right in desiring and encouraging more population. Increase may, for some temporary reason, be essential to their prosperity. But those who live, as I do, among thousands of creatures in a state of semi-starvation will realize that too few is better than too many, and will acknowledge the wisdom of Ecclesiasticus who said "Desire not a multitude of unprofitable children."

But at least it is often urged that the decline in the birth-rate of the intelligent and successful sections of the population—I am speaking of the older communities—is to be regretted. Even this cannot be granted without qualification. As the biologist knows, differentiation is indispensable to progress. If population were homogeneous civilization would stop. In every army the officers must be comparatively few. Consequently, if the upper strata of the community produce more children than will recruit their numbers some must fall into the lower strata and increase the pressure there. Statisticians tell us that an average of four children under present conditions is sufficient to keep the number constant, and as the expectation of life is steadily improving we may perhaps contemplate some diminution of that number without alarm.

In the study of history biological treatment is only beginning to be applied. For us the causes of the success and failure of races are physiological events, and the progress of man has depended upon a chain of these events, like those which have resulted in the "improvement" of the domesticated animals and plants. It is obvious, for example, that had the cereals never been domesticated cities could scarcely have existed. But we may go further, and say that in temperate countries of the Old World (having neither rice nor maize) populations concentrated in large cities have been made possible by the appearance of a "thrashable" wheat. The ears of the wild wheats break easily to pieces, and the grain remains in the thick husk. Such wheat can be used for food, but not readily. Ages before written history began, in some unknown place, plants, or more likely a plant, of wheat lost the dominant factor to which this brittleness is due, and the recessive, thrashable wheat resulted. Some man noticed this wonderful novelty, and it has been disseminated over the earth. The original variation may well have occurred once only, in a single germ-cell.

So must it have been with Man. Translated into terms of factors, how has that progress in control of nature which we call civilization been achieved? By the sporadic appearance of variations, mostly, perhaps all, consisting in a loss of elements, which inhibit the free working of the mind. The members of civilized communities, when they think about such things at all, imagine the process a gradual one, and that they themselves are active agents in it. Few, however, contribute anything but their labor; and except in so far as they have freedom to adopt and imitate, their physiological composition is that of an earlier order of beings. Annul the work of a few hundreds—I might almost say scores—of men, and on what plane of civilization should we be? We should not have advanced beyond the mediæval stage without printing, chemistry, steam, electricity, or surgery worthy the name. These things are the contributions of a few excessively rare minds. Galton reckoned those to whom the term "illustrious" might be applied as one in a million, but in that number he is, of course, reckoning men famous in ways which add nothing to universal progress. To improve by subordinate invention, to discover details missed, even to apply knowledge never before applied, all these things need genius in some degree, and are far beyond the powers of the average man of our race; but the true pioneer, the man whose penetration creates a new world, as did that of Newton and of Pasteur, is inconceivably rare. But for a few thousands of such men, we should perhaps be in the Palaeolithic era, knowing neither metals, writing, arithmetic, weaving, nor pottery.

In the history of art the same is true, but with this remarkable difference, that not only are gifts of artistic creation very rare, but even the faculty of artistic enjoyment, not to speak of higher powers of appreciation, is not attained without variation from the common type. I am speaking, of course, of the non-Semitic races of modern Europe, among whom the power, whether of making or enjoying works of art, is confined to an insignificant number of individuals. Appreciation can in some degree be simulated, but in our population there is no widespread physiological appetite for such things. When detached from the centers where they are made by others most of us pass our time in great contentment, making nothing that is beautiful, and quite unconscious of any deprivation. Musical taste is the most notable exception, for in certain races—for example, the Welsh and some of the Germans—it is almost universal. Otherwise artistic faculty is still sporadic in its occurrence. The case of music well illustrates the application of genetic analysis to human faculty. No one disputes that musical ability is congenital. In its fuller manifestation it demands sense of rhythm, ear, and special nervous and muscular powers. Each of these is separable and doubtless genetically distinct. Each is the consequence of a special departure from the common type. Teaching and external influences are powerless to evoke these faculties, though their development may be assisted. The only conceivable way in which the people of England, for example, could become a musical nation would be by the gradual rise in the proportional numbers of a musical strain or strains until the present type became so rare as to be negligible. It by no means follows that in any other respect the resulting population would be distinguishable from the present one. Difficulties of this kind beset the efforts of anthropologists to trace racial origins. It must continually be remembered that most characters are independently transmitted and capable of such recombination. In the light of mendelian knowledge the discussion whether a race is pure or mixed loses almost all significance. A race is pure if it breeds pure and not otherwise. Historically we may know that a race like our own was, as a matter of fact, of mixed origin. But a character may have been introduced by a single individual, though subsequently it becomes common to the race. This is merely a variant on the familiar paradox that in the

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[*] An address delivered at Sydney, Australia, by Prof. William Bateson, M.A., F.R.S., President, before the British Association for the Advancement of Science.

course of time if registration is accurate we shall all have the same surname. In the case of music, for instance, the gift, originally perhaps from a Welsh source, might permeate the nation, and the question would then arise whether the nation, so changed, was the English nation or not.

Such a problem is raised in a striking form by the population of modern Greece, and especially of Athens. The racial characteristics of the Athenian of the fifth century B. C. are vividly described by Galton in "Hereditary Genius." The fact that in that period a population, numbering many thousands, should have existed, capable of following the great plays at a first hearing, reveling in subtleties of speech, and thrilling with passionate delight in beautiful things, is physiologically a most singular phenomenon. On the basis of the number of illustrious men produced by that age Galton estimated the average intelligence as at least two of his degrees above our own, differing from us as much as we do from the negro. A few generations later the display was over. The origin of that constellation of human genius which then blazed out is as yet beyond all biological analysis, but I think we are not altogether without suspicion of the sequence of the biological events. If I visit a poultry-breeder who has a fine stock of thoroughbred game fowls breeding true, and ten years later—that is to say ten fowl-generations later—I go again and find scarcely a recognizable game-fowl on the place, I know exactly what has happened. One or two birds of some other or of no breed must have strayed in and their progeny been left undestroyed. Now in Athens we have many indications that up to the beginning of the fifth century so long as the phratries and gentes were maintained in their integrity there was rather close endogamy, a condition giving the best chance of producing a homogeneous population. There was no lack of material from which intelligence and artistic power might be derived. Sporadically these qualities existed throughout the ancient Greek world from the dawn of history, and, for example, the vase-painters, the makers of the Tanagra figurines, and the gem-cutters were presumably pursuing family crafts, much as are the actor-families[1] of England or the professorial families of Germany at the present day. How the intellectual strains should have acquired predominance we cannot tell, but in an in-breeding community homogeneity at least is not surprising. At the end of the sixth century came the "reforms" of Cleisthenes (507 B. C.), which sanctioned foreign marriages and admitted to citizenship a number not only of resident aliens, but also of manumitted slaves. As Aristotle says, Cleisthenes legislated with the deliberate purpose of breaking up the phratries and gentes, in order that the various sections of the population might be mixed up as much as possible, and the old tribal associations abolished. The "reform" was probably a recognition and extension of a process already begun; but is it too much to suppose that we have here the effective beginning of a series of genetic changes which in a few generations so greatly altered the character of the people? Under Pericles the old law was restored (451 B. C.), but losses in the great wars led to further laxity in practice, and though at the end of the fifth century the strict rule was re-enacted that a citizen must be of citizen-birth on both sides, the population by that time may well have become largely mongrelized.

Let me not be construed as arguing that mixture of races is an evil; far from it. A population like our own, indeed, owes much of its strength to the extreme diversity of its components, for they contribute a corresponding abundance of aptitudes. Everything turns on the nature of the ingredients brought in, and I am concerned solely with the observation that these genetic disturbances lead ultimately to great and usually unforeseen changes in the nature of the population.

Some experiments of this kind are going on at the present time, in the United States, for example, on a very large scale. Our grandchildren may live to see the characteristics of the American population entirely altered by the vast invasion of Italian and other South European elements. We may expect that the Eastern States, and especially New England, whose people still exhibit the fine Puritan qualities with their appropriate limitations, absorbing little of the alien elements, will before long be in feelings and aptitudes very notably differentiated from the rest. In Japan, also, with the abolition of the feudal system and the rise of commercialism, a change in population has begun which may be worthy of the attention of naturalists in that country. Till the revolution the Samurai almost always married within their own class, with the result, as I am informed, that the caste had fairly recognizable features. The changes of 1868 and the consequent impoverishment of the Samurai have brought about a beginning of disintegration which may not improbably have perceptible effects.

How many genetic vicissitudes has our own peerage undergone! Into the hard-fighting stock of mediæval and Plantagenet times have successively been crossed the cunning shrewdness of Tudor statesmen and courtiers, the numerous contributions of Charles II and his concubines, reinforcing peculiar and persistent attributes which popular imagination especially regards as the characteristic of peers, ultimately the heroes of finance and industrialism. Definitely intellectual elements have been sporadically added, with rare exceptions, however, from the ranks of lawyers and politicians. To this aristocracy art, learning, and science have contributed sparse ingredients, but these mostly chosen for celibacy or childlessness. A remarkable body of men, nevertheless; with an average "horse-power," as Samuel Butler would have said, far exceeding that of any random sample of the middle-class. If only man could be reproduced by budding what a simplification it would be! In vegetative reproduction heredity is usually complete. The Washington plum can be divided to produce as many identical individuals as are required. If, say, Washington, the statesman, or preferably King Solomon, could similarly have been propagated, all the nations of the earth could have been supplied with ideal rulers.

Historians commonly ascribe such changes as occurred in Athens, and will almost certainly come to pass in the United States, to conditions of life and especially to political institutions. These agencies, however, do little unless they are such as to change the breed. External changes may indeed give an opportunity to special strains, which then acquire ascendency. The industrial developments which began at the end of the eighteenth century, for instance, gave a chance to strains till then submerged, and their success involved the decay of most of the old aristocratic families. But the demagogue who would argue from the rise of the one and the fall of the other that the original relative positions were not justifiable altogether mistakes the facts.

Conditions give opportunities but cause no variations. For example, in Athens, to which I just referred, the universality of cultivated discernment could never have come to pass but for the institution of slavery which provided the opportunity, but slavery was in no sense a cause of that development, for many other populations have lived on slaves and remained altogether inconspicuous.

The long-standing controversy as to the relative importance of nature and nurture, to use Galton's[2] "convenient jingle of words," is drawing to an end, and of the overwhelmingly greater significance of nature there is no longer any possibility of doubt. It may be well briefly to recapitulate the arguments on which naturalists rely in coming to this decision both as regards races and individuals. First as regards human individuals, there is the common experience that children of the same parents reared under conditions sensibly identical may develop quite differently, exhibiting in character and aptitudes a segregation just as great as in their colors or hair forms. Conversely all the more marked aptitudes have at various times appeared and not rarely reached perfection in circumstances the least favorable for their development. Next, appeal can be made to the universal experience of the breeder, whether of animals or plants, that strain is absolutely essential, that though bad conditions may easily enough spoil a good strain, yet that under the best conditions a bad strain will never give a fine result. It is faith, not evidence, which encourages educationists and economists to hope so greatly in the ameliorating effects of the conditions of life. Let us consider what they can do and what they cannot. By reference to some sentences in a charming though pathetic book, "What Is, and What Might Be," by Mr. Edmond Holmes, which will be well known in the educational section, I may make the point of view of us naturalists clear. I take Mr. Holmes's pronouncement partly because he is an enthusiastic believer in the efficacy of nurture as opposed to nature, and also because he illustrates his views by frequent appeals to biological analogies which help us to a common ground. Wheat badly cultivated will give a bad yield, though, as Mr. Holmes truly says, wheat of the same strain in similar soil well cultivated may give a good harvest. But, having witnessed the success of a great natural teacher in helping unpromising peasant children to develop their natural powers, he gives us another botanical parallel. Assuming that the wild bullace is the origin of domesticated plums, he tells us that by cultivation the bullace can no doubt be improved so far as to become a better bullace, but by no means can the bullace be made to bear plums. All this is sound biology; but translating these facts into the human analogy, he declares that the work of the successful teacher shows that with man the facts are otherwise, and that the *average rustic* child, whose normal ideal is "bullacehood," can become the rare exception, developing to a stage corresponding with that of the plum. But the naturalist knows exactly where the parallel is at fault. For the wheat and the bullace are both breeding approximately true, whereas the human crop, like jute and various cottons, is in a state of polymorphic mixture. The population of many English villages may be compared with the crop which would result from sowing a bushel of kernels gathered mostly from the hedges, with an occasional few from an orchard. If anyone asks how it happens that there are any plum-kernels in the sample at all, he may find the answer perhaps in spontaneous variation, but more probably in the appearance of a long-hidden recessive. For the want of that genetic variation, consisting probably, as I have argued, in loss of inhibiting factors, by which the plum arose from the wild form, neither food, nor education, nor hygiene can in any way atone. Many wild plants are half-starved through competition, and transferred to garden soil they grow much bigger; so good conditions might certainly enable the bullace population to develop beyond the stunted physical and mental stature they commonly attain, but plums they can never be. Modern statesmanship aims rightly at helping those who have got sown as wildings to come into their proper class; but let not any one suppose such a policy democratic in its ultimate effects, for no course of action can be more effective in strengthening the upper classes while weakening the lower.

In all practical schemes for social reform the congenital diversity, the essential polymorphism of all civilized communities must be recognized as a fundamental fact, and reformers should rather direct their efforts to facilitating and rectifying class-distinctions than to any futile attempt to abolish them. The teaching of biology is perfectly clear. We are what we are by virtue of our differentiation. The value of civilization has in all ages been doubted. Since, however, the first variations were not strangled in their birth, we are launched on that course of variability of which civilization is the consequence. We cannot go back to homogeneity again, and differentiated we are likely to continue. For a period measures designed to create a spurious homogeneity may be applied. Such attempts will, I anticipate, be made when the present unstable social state reaches a climax of instability, which may not be long hence. Their effects can be but evanescent. The instability is due not to inequality, which is inherent and congenital, but rather to the fact that in periods of rapid change like the present, convection-currents are set up such that the elements of the strata get intermixed and the apparent stratification corresponds only roughly with the genetic. In a few generations under uniform conditions these elements settle in their true levels once more.

In such equilibrium is content most surely to be expected. To the naturalist the broad lines of solution of the problems of social discontent are evident. They lie neither in vain dreams of a mystical and disintegrating equality, nor in the promotion of that malignant individualism which in older civilizations has threatened mortification of the humbler organs, but rather in a physiological co-ordination of the constituent parts of the social organism. The rewards of commerce are grossly out of proportion to those attainable by intellect or industry. Even regarded as compensation for a dull life, they far exceed the value of the services rendered to the community. Such disparity is an incident of the abnormally rapid growth of population and is quite indefensible as a permanent social condition. Nevertheless capital, distinguished as a provision for offspring, is a eugenic institution; and unless human instinct undergoes some profound and improbable variation, abolition of capital means the abolition of effort; but as in the body the power of independent growth of the parts is limited and subordinated to the whole, similarly in the community we may limit the powers of capital, preserving so much inequality of privilege as corresponds with physiological fact.

At every turn the student of political science is confronted with problems that demand biological knowledge for their solution. Most obviously is this true in regard to education, the criminal law, and all those numerous branches of policy and administration which are directly concerned with the physiological capacities of mankind. Assumptions as to what can be done and what cannot be done to modify individuals and races have continually to be made, and the basis of fact on which such decisions are founded can be drawn only from biological study.

A knowledge of the facts of nature is not yet deemed an essential part of the mental equipment of politicians; but as the priest, who began in other ages as medicine-man, has been obliged to abandon the medical parts of his practice, so will the future behold the schoolmaster, the magistrate, the lawyer, and ultimately the statesman, compelled to share with the naturalist those functions which are concerned with the physiology of race.

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[1] For tables of these families, see the Supplement to *Who's Who in the Theater*.

Electrical Driving for Rolling Mills—I*

Its Adaptation to Existing Steam-Driven Plants

By L. Rothera

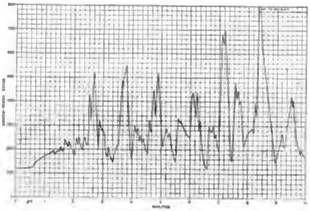
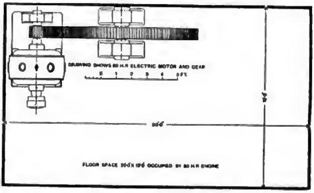


Fig. 1.—Power-demand of a sheet mill driven by a 600 horse-power motor.


DRAWING SHOWS 80 H.P. ELECTRIC MOTOR AND GEAR
0 1 2 3 4 5 FT.
FLOOR SPACE 30'6" × 18'6" OCCUPIED BY 60 H.P. ENGINE
Fig. 2.—Relative floor space taken up by a 60 horse-power engine and an 80 horse-power motor.

The question of the application of electrical driving to existing rolling mills is one which is of the greatest importance where steel, iron and other metal works have been in existence for a considerable number of years, and where the question is not the best method of putting up new works, but the best method of making an old works so economical that it can compete successfully with others which have only within a later period entered this field, and have, consequently, been able to make use of the latest advancements of science.

The subject of this paper can perhaps best be dealt with by dividing it up into two parts:

(I.) The conditions which render the application of the electrical drive desirable.

(II.) The method of application of the drive.

Taking first the considerations which render the application desirable, there are a number of conditions, any one of which may prove the deciding factor in the employment of electricity. Perhaps four such considerations are the most important namely:

1. Economy of running.
2. Improved drive.
3. Considerations of space.
4. Greater use of existing plant.

While it is quite possible that any one of the above considerations may in itself prove sufficient to warrant a change over from a steam to an electrical drive, yet it is more often a combination of the four, together with other considerations not mentioned, which makes the employment of an electrical drive the only one to be considered when a change is necessary.

1. *Economy of Running.*—Dealing first with the economy of running, that is, cost of power per ton rolled, it is, of course, not possible to make any general statement to the effect that in every case the electrical drive will prove more economical than the steam drive, as this depends entirely on local conditions, which differ to such an extent that it is only possible in a paper such as this to indicate a few of the more important ones. Instancing some of these:

The first main factor is the cost of electrical energy. The cost for power will vary very widely in accordance with the method of generating power, and in steel and iron works particularly the question must often be considered as to whether a central station in the works themselves, driven either by gas, live steam raised by hand-firing, steam raised from waste heat, or exhaust steam, is not the most economical method of obtaining the necessary electric power. A very low figure has been, and is being, obtained under certain conditions which represent the most economical method at present known of using available facilities. The method referred to is the employment of blast-furnace gas, coke-oven gas, or a mixture of the two, to drive gas-engines for generating electric power, and using the power thus obtained for driving the steel works plant by electric motors. When it is realized that between two and three times the power is available from the gas so employed to that obtainable if the gas is burnt under boilers for the purpose of raising steam, the economy of this method is self-evident.

The charges made by supply companies vary, naturally, within wide limits, depending largely on the size of the station, cost of coal, etc., and also on the nature of the demand for power; that is, whether night or day load, and whether continuous or not, and also on the quantity of power required per annum.

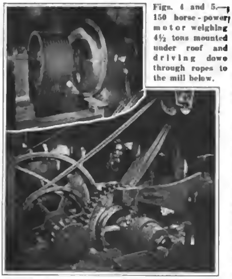

Figs. 4 and 5.—150 horse-power motor weighing 4½ tons mounted under roof and driving down through ropes to the mill below.

Fig. 6.—View of the four mills driven by above motor.

It is, of course, manifest that with a low cost of purchased power there is little, if any, advantage in putting down a central station in the works themselves to be driven by steam, unless the necessary steam is available from waste heat boilers.

When waste heat is available for raising steam, or exhaust steam can be employed, the conditions are quite altered, as when the coal cost, which represents usually over one half of the total cost of power generation, can be ignored, the cost of generation is so low that any works would be well advised to install their own generating plant.

The cost of driving by steam varies fairly considerably in different parts of the country, depending on the cost of coal available, cost of water, labor and other charges, but the fact that motors have been put down, even in cases where power has to be purchased at the highest price, goes far to prove that either the cost of driving by steam is equal to, or greater than, the cost of driving by electricity, or that some of the conditions mentioned later have proved so weighty that the electrical drive has been judged the most satisfactory one to employ.

The second factor on which the economy largely depends is the lay-out of the works. Let us consider the case of a works which originally started in a fairly small way, but which has extended very largely, and in which the boiler plant has remained centralized. The natural effect of this would be a very large number of long steam-pipe lines, all of them acting the part of condensers, and probably a number of them leaking very considerably, this condensation and leakage taking place continuously, whether the engines, which the pipe-lines supply, are working or not. These conditions will, to a large extent, hold even in the case of a works where there are several boiler stations, and the quantity of coal used per year in making up for pipe-line losses and wastage is a very heavy factor in the year's coal bill.

As against this wasteful condition must be taken the economical method of electric power transmission, which is carried out by small cables which can be put up anywhere quite out of the way, and in which no loss takes place when the machines to which they convey power are not running, and in which only a small fraction of loss takes place when the machines are running.

In an old works, moreover, there will be a large number of auxiliary machines driving shears, saws, punching machines, etc., which are working under most uneconomical conditions, being nearly in every case non-condensing, and often almost indistinguishable when working, due to the steam leakage taking place around them.

Contrasting the case of a small motor drive, where the efficiency is practically 88 per cent and where power is being generated under the most economical conditions, the gain in economy is enormous, and it is now an acknowledged fact that under anything like reasonable conditions of electric power cost the auxiliary plant in a mill is much better driven by means of electric motors.

A third factor is the class of work done. As is well known, the steam-engine, while efficient on steady continuous load, becomes very inefficient on a widely fluctuating load. This is a condition which is not nearly so pronounced in the case of an electric motor drive, due to the fact that the efficiency over a very wide range, say from half-load up to 100 per cent overload, varies only to the extent of 2 or 3 per cent, while the steam consumption of an engine may vary as much as 7 to 9 per cent. When there is a considerable length of piping in conjunction with the engine the inefficiency in the latter case is more pronounced, as continual radiation losses are taking place from the pipe-line whether the engine is working or standing still. The amount of steam consumed per useful horse-power will be very materially increased through this source of loss. It may thus be generally stated that the greater the fluctuations in the load, the more advantageous the electrical drive appears. As the load on a rolling mill is, in most cases, a very variable one, varying possibly from practically no-load to nearly 100 per cent overload, the economy of the efficient electrical drive is apparent.

As an instance of this, let us take the case of a sheet mill where the average power-demand, as is shown very clearly from the Fig. 1, represents approximately one third of the normal power of the motor, while the peak load represents practically 50 per cent overload on the motor. This curve is an experimental one taken on a mill driven by a 600 horse-power motor when working under normal working conditions. Assuming the maximum overload which the engine would take to be 25 per cent, the normal horse-power of the engine would have to be chosen at 720 horse-power to deal with the peak loads, so that one third load on the motor, namely, 200 horse-power, would represent only about 28 per cent of the normal engine power. The efficiency of the motor at third load would be approximately 4 per cent less than at full load, while the steam consumption of the engine would be increased at least 12 per cent, not taking into account the losses in the pipe-line, which are considerable, due to the fact that the steam-piping has to be designed of sufficient capacity to take the full rush of steam to meet the overload condition on the engine.

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* Paper read before the Institution of Mechanical Engineers.

Under the question of economy must also be taken the cost of supervision of the running plant. In a large works where there are a number of engines, the running and oiling of the same becomes the task of a considerable number of men. This number can be very materially reduced where motor drives are employed, owing to the fact, that, if properly designed, the motors will run for long periods without any attention whatever, and inspection once a day is all that is necessary. One electrician, to start up the plant in the morning and to pay a periodical visit to the motors throughout the day, can deal with almost any number of machines. Contrast this with the necessity of one driver for each large engine, and a number of greasers for the small engines, and the saving to be effected per annum is very considerable.

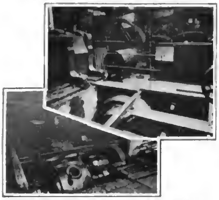
2. *Improved Drive.*—With regard to the question of improved drive, it is an undisputed fact that a steady uniform turning moment produces a better class of rolled material than is the case with a pulsating drive. Even under the best conditions of engine practice a considerable variation in the turning moment is bound to occur, and in this respect the electric motor with its uniform constant torque is far superior.

Another feature very noticeable with the motor drive is the faster working consequent on the fact that, with the even turning moment, there is not the same tendency for the rolls to fail to grip the metal. Also, due to the overload capacity of the motor being in excess of that of an engine, the drop in speed while the metal is passing through the rolls is much less with the electric drive than with the steam drive, and in fact the amount of the drop can be regulated at will in the former case; this results in a higher average speed of rolling and consequent increased output from the mill.

Again, in rolling-mill work, one of the essentials of the drive is that of a good overload capacity. The modern electric motor will take a momentary peak load up to 100 per cent in excess of its normal load without any risk of injury, and is thus enabled to pull a piece of metal through the rolls when an engine of the same normal power would fail to do so, with consequent delay and loss on the mill. The effect of this property of the electric motor is that, when making a comparison between the cost of an electrical, as compared with a steam drive, it is not fair to take into account the same size of the steam-engine and of motor. A larger normal horse-power of the steam-engine would be necessary to give the same maximum turning moment conditions which the motor would give.

The effect of this increase in the size of the engine is to raise the normal horse-power as compared with the average horse-power required, with resulting worse steam consumptions, as is clearly shown above. In addition, larger steam-piping would be necessary to enable the full overload to be carried, which again would prove an increased source of loss.

Figs. 7, 8, and 9.—Motor 250 horse-power, 300 revolutions, driving eleven pairs of rolls.



Figs. 10 and 11.—Two motors (275 horse-power and 100 horse-power) working in a pit below the floor. Gear drive to sheet mill.

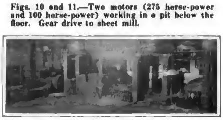


Fig. 12.—Direct-coupled electrical drive by means of long intermediate spindle.

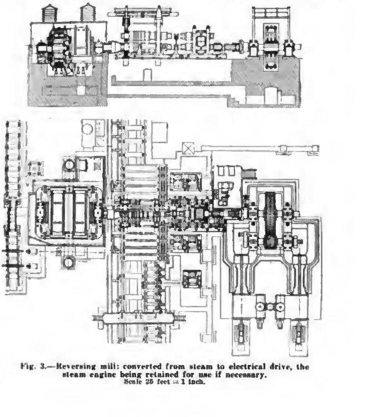


Fig. 3.—Reversing mill: converted from steam to electrical drive, the steam engine being retained for use if necessary. Scale 25 feet = 1 inch.

Another point in favor of the electrical drive is the ease of starting and stopping the plant, so that, in many cases, it is found practicable when the mill is idle for short periods to shut the motor down, whereas it would not be considered in the case of a steam-engine on account of the labor involved.

A further feature, which is also in favor of the electrical drive, and the importance of which is perhaps only appreciated by those who are acquainted with the electrical drive, is the ease of determining for every pass the power being demanded to roll. Electrical instruments will show, with great exactitude, the demand for power at any moment, and it is possible by perhaps somewhat varying the draughting of the rolls, in accordance with these readings, to materially reduce the energy consumption per ton rolled.

3. *Considerations of Space.*—This condition is, of course, of particular weight in the case of works situated in the center of the town where it may be desired either to put down new mills, or to modify existing mills, to allow of larger operations being carried out. This condition is of such importance that in many cases it has been able to overcome the drawback of a heavy charge for power. When the size of a motor of moderate speed is taken and compared with the size of engine of the same power, this advantage is very clearly seen. The illustration, Fig. 2, shows the floor space taken up by an engine which gives a maximum horse-power of 60, and superimposed to the same scale is shown the 80 horse-power motor, which is replacing the engine.

Fig. 4 shows an arrangement which has been carried out in the Birmingham district where the 150 horse-power motor, weighing 4½ tons, is mounted right up under the roof driving down through ropes on to the mill below. Fig. 5 shows the drive on to the mills, and Fig. 6 a view of the four mills driven from this motor. This last view shows very clearly how full the works are, and how important it is to save every square foot of space available. In this particular instance the doing away of the old beam-engine and the replacing of the same by the motor saved a floor area of over 40 square yards, and this space has been fully utilized by the installation of additional machinery.

Fig. 7 shows another drive in the Birmingham district where a motor has been put down to replace an engine drive, and Fig. 8 shows another view which gives a very clear idea as to the method of driving the eleven pairs of rolls which are worked from this motor. Fig. 9 shows the site of the old engine, the crankshaft being where the coupling-box is seen in the photo, and in this case an area of no less than 76 square yards was saved by the change-over. The motor is of 250 horse-power running at 300 revolutions per minute.

Figs. 10 and 11 show another arrangement which has been adopted in the Birmingham district where two motors of 275 horse-power and 100 horse-power respectively have been installed for driving some sheet mills. There was no space available on the ground level, and the result has been that the motors have been put in a pit below the floor and boarded over. The space is so restricted between the mills that the men actually work on the boards above the motors. A suitable gear drive has been arranged, as can be seen by the illustration, between the motor and the mill.

4. *Increased Power.*—A case very often arises where a mill manager is anxious to enlarge the power of his driving engines, and the question then arises as to how this is to be done. In a great many cases the amount of steam available would not be sufficient to allow of the installation of larger engines without expensive alterations to boiler plant, and it is in such a case that the installation of electrical plant can show very favorably. Given below is an example based on actual figures illustrating this point. The case is one of an iron works where a proportion of the steam used is raised from waste heat boilers over puddling furnaces, and the remainder of the steam required is raised by hand-firing. The question may arise as to how:

(1) The hand-firing can be dispensed with, and
(2) An increased power obtained.

Assume that the works has four rolling mills, consisting of a forge train, two merchant mills, and a sheet mill, the mills being driven by two engines, one driving the forge and one merchant mill, the other driving the sheet mill, and the other merchant mill. Let us take an output of 30 tons of puddled bars from the forge train, 18 tons of flats, rounds, etc., per turn from the merchant mill attached to this engine, 8 tons per turn from the sheet mill, and 12 tons of rounds from this merchant mill. In order to obtain the above output, a total quantity of coal of approximately 1,980 tons per month would be used in the furnaces, and in addition approximately 270 tons of coal under hand-fired boilers. Taking steam evaporation from the furnaces at three times the weight of coal consumed, the steam raised from the furnaces would be 13,300,000 pounds per month, and from the steam under the boilers, assuming seven times evaporation, 1,240,000 pounds, that is, the total quantity of steam per hour would be 30,000 pounds. The whole of this steam is at present being employed in driving the above two engines, steam-hammers and a few small auxiliary engines.

Suppose it was proposed to replace the engines by an electrical drive, the problem is to find out whether any economy would result. Under the above conditions of output, it can be taken that the total number of units to roll the tonnage mentioned would be approximately 400 kilowatts per hour. In order to deal with this, and also the auxiliary plant, which would perhaps take 70 kilowatts, a 500-kilowatt turbine would be installed. The steam-pressure raised in boilers above puddling furnaces is usually very low, about 40 pounds per square inch, and under these conditions a steam consumption of approximately 20.4 pounds per kilowatt-hour would be necessary, that is, the total quantity of steam required would be 10,500 pounds per hour. The amount of steam produced from the waste heat boilers alone is 23,000 pounds, and taking the steam required for the hammers at 4,000 pounds per hour, there is left available no less than sufficient steam to raise a further 400 kilowatts, and at the same time give a saving in hand-firing of 270 tons of coal per month.

The above figures, which speak for themselves, and which are in no way exaggerated, show conclusively how, under such conditions, by the installation of electrical plant, an extremely large saving per annum can be made, and at the same time a very largely increased power rendered available from steam already existing. An actual instance of this is the case of an iron works where three of the main engines and all the auxiliaries were replaced by motors of very considerably increased power and a central station was put down for supplying them. Since the electrification no fewer than eight hand-fired boilers have been permanently knocked off.

Another interesting case to consider is that of a reversing mill plant in which the roughing and finishing mills are driven from the same engine. Suppose it is desired to increase the output of the mill, a method of doing so is to divide the mill up, driving the finishing mill and roughing mill separately. Assuming that the question of capital cost renders the complete electrification of the mill impossible, then the existing engine can be retained for driving the finishing mill, and under the usual conditions of merchant mill work, the exhaust steam from the reversing mill-engine will be sufficient to generate enough power to drive the roughing mill electrically. While by doing this the output of the mill may be practically doubled, yet the drive will not be so economical as it would be if the whole plant was driven electrically, due to the better steam consumption of a turbine driving a generating set as compared with that of a reversing steam-engine working under rolling-mill conditions, this better economy more than counter-balancing the losses due to the conversion into electrical energy.

The above conditions are, perhaps, particularly favorable for the installation of electrical drive, but there are a very large number of considerations which come into question, which must be very carefully weighed before deciding that the electrical drive will not pay, even if the actual cost of electricity consumed per ton rolled is in excess of the corresponding steam cost; for instance, the cost of maintenance on an electric motor is very much less than that of a steam-engine. The cost of supervision is also very much less. The reduction in the oil consumed per annum is another item which must not be lost sight of, and in one particular case where electrical plant replaced steam drives, the reduction in the oil consumed was 80 per cent. When, in addition to the above advantages, the absence of steam-pipes with their cost of upkeep, and the cleanliness of the electric drive, are remembered, there are many cases where these advantages alone outweigh, perhaps, a slightly increased capital cost, or a power consumption cost, which would appear to be more than that of a steam-engine, when taking into consideration alone the *steam consumption* of the engine.

A point which should always be borne in mind is, that although an engine may be designed to be very economical indeed on full-load, yet the conditions of a rolling mill are such that these conditions are practically never obtained, and the only fair method of comparing the electrical with the steam drive, is to take, in the latter case, the *cost of coal per annum*, and not the steam consumption of the engine, and contrast this with the power cost of the motor.

(To be concluded.)

Recent Developments in Marine Propulsion*

The Compound Turbine, with Reduction Gear, and Gas and Oil Engine

During the one hundred years that the reciprocating steam engine has been used for the propulsion of ships, it has been continuously improved in reliability, handiness, and efficiency, and it had no competitor until a little more than a dozen years ago, when the Parsons turbine began to claim attention as a serious rival for the propulsion of high-speed, high-powered ships. The improvements in the efficiency of the reciprocating steam engine have been due to the conjoint effects of improved materials and tools for the construction of the boilers and the engines and to increasing knowledge of the scientific principles relating to the thermal and mechanical problems involved in the design and construction of the engine and its auxiliaries. The introduction of the compound, triple, and quadruple expansion engines, associated in each case with considerable increases in steam pressure, enabled successive and notable increases to be obtained both in the thermal and mechanical efficiencies of the engine, and the successful re-introduction of superheating has rendered it possible still further to reduce the consumption of coal per horse-power hour by from 10 to 20 per cent under favorable conditions.

In all reciprocating engines the piston and other reciprocating parts have to be stopped and started again twice for each revolution of the crankshaft, and the forces transmitted to the bed-plate of the engine, due to the starting and stopping of the reciprocating masses, are so great that unless balanced they cause great vibration of both the engine and of the ship. Increased knowledge has rendered it possible entirely to balance these inertia forces and couples within the engine framing itself, but for a complete balance the minimum number of cranks required is five, although it is possible to get an approximate balance in an engine with four cranks.

In order to get rid of some of the mechanical defects of the reciprocating engine, innumerable inventors have striven to produce a successful type of rotary steam engine, but all these efforts were in vain until Parsons solved the problem by inventing his compound steam turbine. This type of engine consists essentially of one moving part only, the turbine drum, which has only rotational motion, and which therefore can be perfectly balanced. The success of the steam turbine for marine propulsion has been due, not to the reduction of steam and coal consumption, but to the absence of vibration in its working, to the reduction in weight and in space occupied for a given power, to its greater simplicity as a machine, to the lower cost of maintenance, and to the great units of power in which it can be constructed. When the turbine can be arranged to run at its best speed its efficiency is at least equal to, and in many cases greater than, the efficiency of the best reciprocating steam engine; but this speed is much greater than the best speed for a screw propeller. In applying a steam turbine for marine propulsion it was necessary to effect a compromise; the turbines were designed to run at a much lower speed than turbines of the same power used for the driving of dynamos, and the screw propellers were made of smaller diameter, and their speed of rotation was increased as compared with propellers driven by reciprocating engines. These modifications involved larger turbines, with more expansion stages, also a reduction in the efficiencies of the turbine and of the propeller. In spite of these difficulties, the direct connected turbine proved itself to be much superior to the reciprocating steam engine for high-speed, high-powered ships.

Owing to the difficulties which I have indicated, the field of application of the direct-coupled steam turbine has been restricted to high-speed, high-powered ships. In order to render the many advantages of the steam turbine available for small-powered, lower-speed ships, Parsons has introduced helical gearing for connecting high-speed turbines to low-speed propeller shafts, and the results of experience already obtained with these geared turbines are so promising as to render it likely that this system will be largely adopted in the immediate future.

The gear ratio varies with the conditions. In the case of the "Vespasian" this ratio is 20, the turbine running at 1,440 revolutions per minute, and the propeller shaft at 72 revolutions per minute. The shaft horse-power at 73 revolutions per minute was 1,080, and the corresponding speed of the ship was 10.58 knots.

In the case of the twin-screw channel steamers "Normania" and "Hantonia," each of which is fitted with geared turbines giving 5,000 shaft horse-power at 19.7 knots, there are four turbines, two of which run at 2,000 revolutions and the other two at 1,400 revolutions, while the propeller shafts both run at 310 revolutions. The results of measurements show that the geared turbined ship "Cairnross" used 15 per cent less coal than her sister ship the "Cairngowan," which is fitted with triple-expansion engines.

The efficiency of Parsons helical gearing is stated to be 98½ per cent, so that the friction loss due to its use is only 1½ per cent, whereas the gain at the turbine is many times this. The high efficiency of the gearing is due to the accuracy with which the teeth are formed, also to the effective means adopted for lubricating the teeth. A spray of oil is continually showered upon the teeth as they enter into mesh with one another, and the resulting films of oil prevent the teeth coming into contact with each other, and the conditions are therefore the same as in a well-lubricated bearing.

In a few ships, a steam turbine has been coupled up in series with quadruple-expansion engines, thus enabling the expansion to be carried further than can be effected in a reciprocating engine, and it is said that this combination has effected a reduction of 20 per cent in steam consumption as compared with the quadruple-expansion engine alone. The complexity of this combination and the successful introduction of the geared turbine will, I think, prevent this combination being widely adopted.

Another method which is being developed as a reducing gear between steam turbines and propeller shaft is the Föttinger hydraulic transmitter.

This transmitter consists essentially of a centrifugal pump and a water turbine combined within the same casing in such a way as to reduce the losses to a minimum. The efficiency of this type of reducing gear is not so high as that of the Parsons gear, but it is stated that in the case of large powers the efficiency may be as high as 90 per cent. This gear has the advantage that it is reversible, and therefore it obviates the need for the go-astern steam turbines and the direction of rotation of the driving steam turbine is never reversed. It thus gets rid of one cause of blade stripping such as occurred, for instance, in the turbines of the "Lusitania." It also enables the power for going astern to be as much as 80 per cent of the go-ahead power, which is very much greater than that usually provided in the go-astern turbines. The maximum power transmitted to one shaft by this gear up to the present is 10,200 horse-power, and the reversal can be effected in from 10 to 12 seconds. This gear is being applied on a German turbine ship of 23,000 horse-power, and the efficiency guaranteed is 90 per cent, but a better result than this is expected. This gear is used on the Holtzapfel gas-propelled vessel, also in connection with Diesel engines. The velocity ratio possible with this gear is only about 6 to 1 with a single-stage arrangement, but with a three-stage combination it may be as high as 30 to 1.

No notable improvements have been made in recent years in the design or in the efficiency of marine boilers, excepting in the case of those used in warships, which are now always of the water-tube type. This type of boiler has not found favor in the ships of the mercantile marine, mainly because it requires more skilled and more careful attention than the ordinary type of marine boiler and because it is of greater importance with it to prevent oil and sea-water being admitted to the boilers. Improvements in condensers and the adoption of the steam turbine reduce these difficulties, and it is likely that for high-powered ships the water-tube boiler will in the near future displace the ordinary type of boiler, because its weight and the space occupied are considerably reduced by its adoption.

Recently, a new type of boiler has been introduced by Prof. Bone which enables great reductions to be made in the size, weight, and cost of boilers. This boiler is of the ordinary multi-tubular type, but it contains neither furnaces nor combustion chambers of the usual type. The tubes are packed with a refractory material and the fuel, gas or oil spray, is burned within the tubes of the boiler. The refractory material greatly increases the rate of combustion and also greatly increases the rate of evaporation. In one boiler the rate of evaporation was over 20 pounds per square foot of tube surface per hour, which is from three to four times as great as that usually attained in marine boilers, and it is stated that the efficiency was over 90 per cent, as compared with from 70 to 80 per cent in boilers of the ordinary type. This boiler cannot, unfortunately, be fired with coal direct. The coal must first be gasified and the gas must be thoroughly cleansed of ash and tar. This boiler therefore would be of no use for marine purposes were it not for the fact that fuel oil when suitably sprayed may be used in conjunction with it. If the results already obtained with this type of boiler are proved to be attainable under regular working conditions at sea with oil fuel, it may displace the water-tube boiler for warships.

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* Abstract of a lecture delivered by Prof. W. H. Watkinson at the Liverpool University. Reproduced from *The Engineer*.

The following comparisons between quadruple-expansion reciprocating engines, ordinary turbines, and geared turbines may be of interest:

	Vessel 480 feet long, trial speed 14¼ knots.		Vessel 600 feet long, trial speed 19½ knots.	
	Quadruple reciprocating.	Geared turbines.	Ordinary turbines.	Geared turbines.
Total weight of machinery in tons	1,345	1,060	3,060	2,910
Weight of coal per hour, tons	4.8	4.1	13.6	12.3
Area of engine-room	1,050	1,050	5,020	3,090
Area of boiler-rooms, without bunkers	2,110	2,030	6,400	6,160

The steam engine, whether of the reciprocating or of the turbine type, has a much lower possible efficiency than the internal combustion engine. If coal is burned without excess of air, the temperature attainable is about 5,200 deg. Fahr., and a perfect engine working between this temperature limit and the temperature of the atmosphere would convert 91 per cent of the heat into work. With a perfect boiler, the weight of coal required per indicated horse-power hour would be only one fifth of a pound, and the weight of oil required would be only 0.133 of a pound.

The maximum temperature attained in the cylinders of gas and oil engines is about 3,000 deg. Fahr., and a perfect cycle working between this temperature and atmospheric temperature would convert 85 per cent of the heat into work, and would use only 0.159 of a pound of oil per indicated horse-power hour. The thermal efficiency actually attained in Diesel engines is about 42 per cent, and the weight of oil per indicated horse-power hour is about one third of a pound, and the weight of oil per brake horse-power hour is about 0.4 of a pound.

The great handicap of the steam engine is the big drop in temperature between the furnace and the steam. The best result yet attained with a steam engine and boiler is a combined efficiency of 17 per cent, and, including engine friction, 15 per cent. It is usually very considerably less than this. With the above efficiency, the weight of coal used per indicated horse-power is equal to 1.08 pound per hour, and the weight of coal per brake horse-power hour works out at 1.22 pound.

The greater possibilities of the internal combustion engine as compared with the steam engine and the results already achieved with marine Diesel engines must compel increasing attention to be given to the development of the internal combustion engine.

With internal combustion engines, the fuel may be either coal or oil, but at present there is no gas producer available suitable for marine purposes, and very few men appear to be devoting themselves to the solution of this important problem. The line of least resistance for marine work is the use of oil fuel, as this does not involve the use of gas producers and their accessories.

The fact, established by actual experience at sea, that the weight of oil required per brake horse-power hour by Diesel engines is only from a quarter to one fifth the weight of coal required with steam engines, whether of the reciprocating or of the turbine type, enables oil fuel to be used with commercial success even when the price of oil is six or seven times the price of coal, because of the savings and advantages obtained with these engines.

For marine purposes in general, oil fuel has many and great advantages over coal. Its heat value per pound is 50 per cent greater than that of good coal, so that even with steamships only two thirds the weight of fuel is required. It can be stored in the double bottom and in other remote parts of the ship. It is self-trimming. It can be put on board in much less time and with entire absence of dirt and dust—with steam plant fewer or smaller boilers are required. Stokers and trimmers are not wanted. It is not liable to spontaneous combustion, and there are no ashes to be got rid of.

It has been estimated that if all the power-propelled ships in existence were driven by Diesel engines of the present realized efficiency, the amount of fuel required per annum would be about 25 million tons. In Germany, owing to a heavy import duty on oil, a great deal of attention has been devoted to the manufacture of oil from coal tar, and practically all the heavy oil engines in Germany are run on tar oil, of which the output during this year will probably amount to about one million tons. This is probably about five times as much as would be required for all the ships of her navy if these were propelled by Diesel engines; and as a Diesel engined ship can carry sufficient oil to enable her to go to any part of the world, fight her battles, and return home without taking in any fresh supplies, the relative advantages which we at present possess, due to our coaling stations, would vanish if she were to adopt Diesel engines for the propulsion of her ships of war. Possibly the realization of this great increase of power has had something to do with the enormous expenditure of energy and money on researches and other experimental work in connection with Diesel engines in Germany.

We, unfortunately, have no natural supply of oil in this country, and if we are to continue to use coal for marine propulsion we must devote ourselves to the evolution of a suitable gas producer. Coal, however, is not a source of heat energy only, but it can be made the source of valuable products, such as sulphate of ammonia and tar. The amount of tar at present produced in this country is sufficient to provide much of the oil which will be required for marine purposes, but we may soon find it more profitable to convert coal into coke or coalite and gas, than to burn raw coal for domestic and power purposes.

Birds and Weather*

By A. Landsborough Thomson

The difficult question of the influence of meteorological conditions on the phenomena of bird migration has fortunately been very thoroughly studied as regards the British area, but we are none the less glad to welcome the recent labors of Dr. Defant on this subject. Dr. Defant as a meteorologist has submitted to a critical examination the data collected some years ago regarding the spring arrival in Austria of some thirty species of birds. He has selected four species for special treatment, and the data cover a period of seven seasons (1897-1903). The published weather reports have supplied all the necessary meteorological data for the corresponding periods.

At the outset of his paper Dr. Defant points out that, while all meteorological factors must be taken into account, the relation of all other conditions to that of atmospheric pressure renders possible a concentrated attention on the latter. A comparison of the ornithological data with the temperature records gave a purely negative result, no direct relation being discoverable. Dr. Defant also rightly insists on the importance of considering the weather of the whole of southern Europe, the conditions prevailing in the actual area of arrival being obviously less important than those in the regions immediately to the south through which the migrants must pass.

The spring immigration of the starling and the lark are treated together, these species showing a detailed similarity in this aspect of their seasonable movements. Tables are given showing that there is no annual variation both in the earliest date of arrival and in the duration of the influx. The period of heavy immigration usually lasts about eight days and the average date of maximum arrival for the seven years was February 23rd, while the average dates for particular years varied from February 12th to March 3rd.

With the partial exception of one year out of the seven it was found that the periods of maximum immigration coincided with periods of low atmospheric pressure in the west and northwest of Europe, and higher pressure in the south, southeast, or east. These conditions give southerly or southeasterly winds in Austria and the countries immediately to the south, and usually rising temperatures. The immigration was all the greater when these favorable conditions had been immediately preceded by a prevalence of high pressure in the north and northwest (or northeast) and low pressure in the east or southeast; such conditions usually entail low temperatures and northerly or northwesterly winds.

Dr. Defant then considers the average daily pressure for the three regions into which he divides southern Europe. These are A = western Asia Minor, the Balkan Peninsula, the Adriatic Sea, and southern Italy; B = the remaining greater part of Italy, the western Mediterranean, and northern Africa; and C = Spain and Portugal. The last named region is soon shown to be irrelevant, and Dr. Defant's second conclusion results from a comparison between A and B. He finds that strong immigration in Austria occurred when the pressure in these regions was relatively higher than on the days immediately before and after and when the pressure in A was higher than in B. The east to west pressure gradient thus formed, when coupled with the effect of the earth's rotation, produces the southeasterly winds characteristic of the type of weather already described as favorable to migration.

The cuckoo and the house martin are then treated in like manner (not jointly as in the previous case, but simultaneously to economize space in tables and graphs). The same two conclusions are arrived at for these immigrations occurring much later in the season than that of the starling and the lark. A second type of weather was also found favorable in the case of the cuckoo, namely, extended high pressure over the whole of central and southern Europe, usually with weak easterly or northeasterly winds. In seasons in which the strongest immigration occurred under such conditions the period of the chief movement was protracted to about nineteen (instead of about nine) days.

Dr. Defant has clearly proved that a certain type of weather is peculiarly favorable for the spring immigration of Austrian birds.

His further speculations are, however, open to serious criticism. He believes that the important factor in this type of weather is the wind and that birds prefer to fly with it behind them. His reasons as to why birds should do so seem to us to be wholly beside the point, and as the much more comprehensive results already obtained in this country are entirely opposed to Dr. Defant's theory, we cannot accept it, however temptingly obvious it may seem, on such very slender grounds.

The alternative theory is that "the winds and the performance, or non-performance of the migratory movements are the effects of a common cause, namely, the particular type of weather prevailing at the time, which may be favorable or unfavorable for the flight of birds. . . ." (Eagle Clarke, "Studies in Bird Migration," 1912, p. 173.)

In the British area there are certain types of weather favorable, respectively, for migration between the British Isles and northern Europe, between the British Isles and Iceland, and between the British Isles and southwestern Europe. The winds accompanying these types of weather *may or may not* be in the same direction as the movements concerned. Furthermore, the same types of weather favor these movements both in autumn and spring, the direction of flight being reversed while the prevailing winds remain the same.

In Dr. Defant's simpler case it so happens that the favorable type of weather he has discovered produces a wind in the same direction as that of immigration from the Balkan Peninsula (his region "A") to Austria; but the immigration from the southwest ("B") probably forms a large part of the movements which were the subject of investigation. It is unfortunate that only the spring migrations have been dealt with. Should the same type of weather with its accompanying winds prove to be favorable to the autumn emigration (as in the case of the British movements), Dr. Defant's theory would be quite untenable.

In the meantime Dr. Defant's selection of wind as the important factor is purely speculative, and his view entails an entirely different relation between birds and weather in Austria from that existing in the British Isles. While rejecting his theory of the importance of wind as unproven and improbable, we feel grateful for the new facts which he has added to our knowledge of bird migration by his most laborious and thorough research.

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[*] "Der Einfluss des Wetters auf die Ankunftszeiten der Zugvögel im Frühling." By Dr. A. Defant, Vienna. Reproduced from *Nature*.

Balancing Internal Combustion Engines

In a paper read before the Institute of Automobile Engineers, F. W. Lanchester considered this important subject at considerable length, and includes a short description of his anti-vibrator and his crankshaft vibration damper. The function of the "anti-vibrator" is to supply a countervailing movement of mass of the same periodicity, and of sufficient magnitude to neutralize the unbalanced octave component of the piston motion. To this end, two reverse rotating balance weights are employed, or two pairs of such weights, each of which supplies a vertical component sufficient to quench one half of the unbalanced piston component, the horizontal component of motion of the rotating masses being arranged to neutralize one another after the style of the balance weights fitted to the crankshaft of the old 12 horse-power Lanchester engine. This device can be employed simultaneously for the correction of the octave vibration and for the elimination of vibration due to piston inertia.

The solution to the torsional vibration trouble with crankshafts has been found by the author to consist in a vibration damper attached to the tail or free end of the crankshaft. This damper in the form fitted by the Daimler Company, comprises a small flywheel mounted to rotate freely on bearings, and in driving connection with the crankshaft through a multi-disk clutch arranged in an oil bath, ordinary viscous cylinder oil being used as lubrication. The damper, so fitted, does not impede rotational motion in the smallest degree—it is carried round with the crankshaft without offering resistance—but it forms an immediate and considerable resistance to anything in the nature of angular or torsional vibration. Since the introduction of this damper, it is stated that all difficulty previously experienced in the driving of valve gear from the tail end of the crankshaft has disappeared.

The Experimental Plotting of Electro-Static Fields

A Simple System Useful in Designing High Tension Insulators

By S. H. Querbocker and Morgan Parsons

No doubt some who read this article will at one time or another have plotted electro-magnetic fields by sprinkling iron filings on a sheet of paper held over a magnet. But how many have plotted the electro-static field between two charged bodies? With the increasing use of high voltages interest in electro-static effects has revived, and methods of plotting these fields have become of interest.

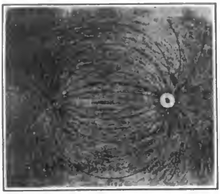

Fig. 3.—Field produced between two 2-centimeter disks placed 15 centimeters apart. The full lines show a field calculated from theory.

One of these methods is comparatively simple and, in outline, is as follows: A thoroughly dried, fine grained, wooden plate is secured and held in a suitable insulating stand, as shown in figure one. The base of this holder is twenty-four by twenty-four inches; the glass tubes are also two feet long; small wooden buttons are set in the top of the tubes to support the corners of the plate; and the two clamps on the back tubes are used to hold the supply leads. With such an arrangement as this any size plate up to 20 by 20 inches may be used. Next a sheet of loose texture paper, such as is used by newspapers, is fastened on the wooden plate with thumb tacks. Terminals of the desired shape are then cut from tinfoil, pasted on the paper, and wired to a source of high voltage through a suitable switching gear. Powdered mica is then sprinkled over the paper in a thin uniform layer. It will not be difficult to do this if a flour shaker is used, and the sprinkling done from well above the paper. Next the voltage is switched on, and the plate tapped gently with a long rod of glass or other insulating material; the operator standing on a non-conducting platform. As the tapping is done the mica will be seen to form into the lines of the field. No one, of course, should be near the apparatus when the voltage is switched on, for in most cases at least 5,000 volts will be necessary to form the field. Though there are several other methods the one outlined above is simple of performance and may be made to produce good results after comparatively little practice.

Sheet mica may be powdered by using a milling cutter, and various sizes produced by changing the speed of cutting. For plates eight by twelve mica that has passed through a twenty mesh sieve and over an eighty mesh one will be found very good. The best results will be obtained on a dry day working with mica that is also thoroughly dried.

If it is desired to make permanent records blueprint paper may be substituted for the loose texture paper mentioned above, and then printed while the mica dust field is still on it. Or a still better modification is to use black paper paraffined rather heavily by dipping. Then proceed as before until the field is formed. Next melt the paraffin sufficiently to set the mica, but not enough to move it from its position. To do this an oven may be used or a lamp bank will serve the purpose. A coat of shellac, sprayed on when the paraffin is cool, will aid in preserving the plate. This latter method was the way the fields were made from which the photographs were taken. The fields will be found to show up very nicely on the black paper. Fig. 2 shows the general layout of the apparatus.

The photographs reproduced here are all from negatives that have not been retouched. Fig. 3 shows the field between two 2-centimeter disks with 15 centimeters between centers. Superimposed on this field is one calculated according to theory, for point sources. The potential difference was 10,000 volts. Allowing for the discrepancy due to the fact that the disks are not exactly point sources, the fields may be said to be alike. Fig. 4 illustrates a needle point at the center of the arc of a circle, and was subject to about 5,000 volts. From this may be seen the well-known fact, that a field is stronger at a point than over a large area. It also shows that this method will indicate the intensity of a field as well as its direction. In Fig. 5 a strip of tinfoil, with sides that follow two equipotential surfaces, is interposed between the two circular disks. This arrangement gives a better distribution of the field than if the sides of the strip had been parallel.

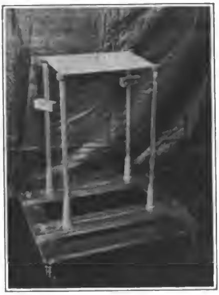

Fig. 1.—Stand used for plotting electro-static field.

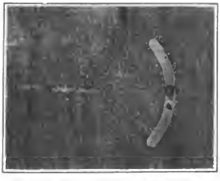

Fig. 4.—Needle point at center of arc of a circle, showing that a field is stronger at a point than over a large area.

The fields obtained in this way are of value in designing high tension insulators, as well as being interesting theoretically. For insulator design work these fields show the distribution on a plane passed through the axis of the insulator. From the standpoint of theory, the best possible shape for an insulator to follow is that of one of the flow lines of the field; practice, however, modifies these shapes.

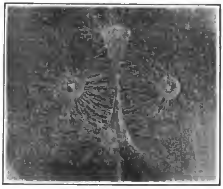

Fig. 5.—An equipotential surface between two disks.

The work from which the above results were obtained was carried on in the alternating current laboratory of the University of Pennsylvania Electrical Engineering Department.

International Volts

In accordance with the decisions of the London conference the silver voltameter is to be used to measure the international ampere, and this in connection with the international ohm may be used to measure international volts. On the other hand, a standard cell whose voltage is expressed in terms of the mean Weston normal cell taken as 1.0183 volts at 20 deg. Cent., is now the recognized method of measuring international volts in accordance with the recommendation of the International Committee on Electrical Units and Standards. The difference between the two measurements will be the same as the difference between the round value 1.0183 volts recommended by the International Committee, and adopted for use by the several countries, and the more exact figure expressing precisely the value found by means of the silver voltameter and a standard resistance, assuming that the errors of measurement are negligible. From a long series of determinations with the voltameter we believe that this difference is about 3 parts in 100,000.

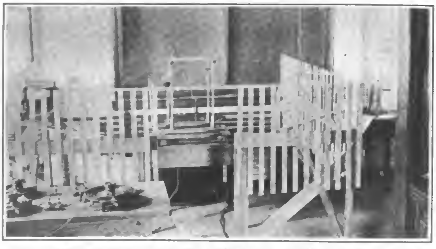

Fig. 2.—General arrangement of apparatus for plotting electro-static field. Note protecting fence around the stand.

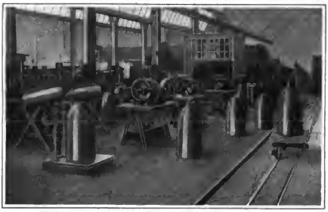

Fig. 2.—Torpedo head shop. These cones enclose the explosive, and are furnished with percussion needles.

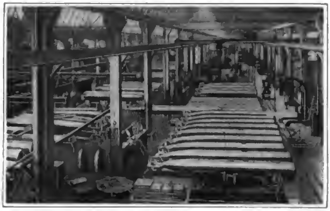

Fig. 3.—Torpedoes ready for delivery. The explosive heads are not affixed until just before they are launched.

The Automobile Torpedo*

The History of the Development of a Remarkable Invention

For a long time the cannon was the main fighting arm for ships. During the last quarter of the last century the struggle for supremacy between it and increasing efficiency in armor was the reason for such improvement that it is to-day at the highest point of perfection it is likely to attain.

But about 1870 there appeared another naval weapon, the self-propelling torpedo, invented and constructed by Whitehead. This showed its potential power during the war between Chile and Peru (1877), but nevertheless, it was only a weak weapon. The diameter of the early torpedo was 13 inches, its weight not far from 400 pounds, and it carried a charge of explosives of only 35 pounds. Its striking distance was limited to 200 meters (656 feet) and its greatest speed in the water was about 8 knots.

The genial inventor of this weapon was born at Bolton-le-Moors, England, January 3rd, 1823. At fourteen he quit school to become an apprentice in a mill in Manchester, where his uncle was superintendent. At twenty-one he was a draughtsman at Marseilles, and three years later he went to Milan, where his occupation was with silk looms. Here he patented a number of important inventions in machinery for weaving. He was next director of the Stabilimento Tecnico, at Trieste, and in 1858 he helped establish at Fiume, not far distant, a marine engineering works which prospered. Of this he became proprietor in 1872, and changed it into a factory for the construction of torpedoes.

The story of the evolution of the Whitehead torpedo is this: In 1860 Capt. Luppis of the Austrian navy conceived the idea of a vessel for coast defense, dirigible from a distance and carrying a charge which when the boat struck a ship or an obstacle would be exploded. In 1864 Whitehead and Luppis associated themselves for the purpose of developing the idea. It was very soon found to be impracticable, but Whitehead thought that the dirigible boat might be changed into a submarine projectile capable of making its own way when launched into the water. The first torpedo was constructed in October, 1866, and despite numerous and important improvements, it was considered even up to the opening of the Russo-Japanese war a weapon of uncertain value. Since that date, however, the opinion of experts has been changed. The first experiments showed that the essential quality to develop was speed, and the efforts were largely along that line for a time. Then on account of the continually greater resistances of the armor of ships it was necessary to increase the explosive charge. Then the development of rapid-fire guns made it more difficult for the torpedo boats to approach their adversaries and greater radius of action was necessary in the torpedoes themselves. The different demands led to gradual increase in the caliber of the projectile, but here the question of weight came as a determining factor. It is necessary not to exceed the weight or dimensions that can easily be handled on shipboard. Next there was the use of compressed air for motive power. It has been through the combination of all these factors by dint of an enormous amount of ingenious invention and adaptation that the modern torpedo has been possible.

The following specifications, compiled from various statements will serve to outline the development of the torpedo.

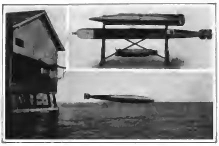

Fig. 1.—Launching trial torpedo.
Insert 1, the first torpedo; 2, torpedo of to-day, 3, dirigible boat of Luppis.

Model of.	Diameter. mm.	Weight. kg.	Speed. knots.	Range. meters.	Charge. kg.
1868 ..	331	180	6-8	200	18
1889 ..	381	432	22	1,500	75
1892 ..	450	...	25	2,000	94
1906 ..	450	650	40	3,000	100
1912 ..	450-533	900	45-48	6,000	130

The model of 1906 was the turning place which made the torpedo a real rival of the cannon. The speed was raised to 40 knots, and the distance possible to 3,000 meters (more than a mile and three quarters). The caliber remained constant, but the projectile was lengthened and new machinery introduced which increased the weight. The type of 1912 shows still further advances, and a range of nearly four miles, but the weight limits its use to vessels of larger, modern dimensions.

Everywhere skilled men have been working for the perfection of the torpedo, and the processes of improvement are everywhere evident, notably in the machinery. By employing larger reservoirs of compressed air the range of its action has increased even up to 10,000 meters. On the other hand it is necessary to travel this distance with such speed that the vessel against which it is aimed cannot run away or maneuver so as to avoid it. One of the processes tending to increased efficiency is the heating of the air. This has been an important step, carrying the solution to grave difficulties, among them the problem of lubrication. Compressed air when liberated is an excellent refrigerant, and it has been found that the temperature of the exhaust is frequently below zero Cent. Such cold produces annoying troubles in freezing the lubricants in a machine which must employ them everywhere, and the high temperature of the air modifies this difficulty.

Various systems are employed for heating the air for torpedo engines. The usual method employed is by burning alcohol either within the air reservoir or in the pipes leading to the motors. The illustration (Fig. 4) shows the device (*SH*) within the tank of compressed air. The advantage of heating the air is shown by the following table of comparison. The speeds are given for different distances from the firing station, the torpedoes actuated by heated air not only attaining a higher early velocity (almost one quarter greater), but maintaining a higher percentage of it through a long run (65 per cent against 57).

Distance.	Speed with cold air.	Speed with heated air.
1,000 meters	35 knots	43 knots
1,500 meters	30 knots	40 knots
2,000 meters	28-25 knots	38 knots
3,000 meters	25-24 knots	32 knots
4,000 meters	18-20 knots	28 knots

Then by another very ingenious device it is possible to give the self-propelling torpedo a trajectory that is effectively rectilinear by furnishing it with a gyroscope governing the rudders. It is possible in this way to keep the axis of the torpedo to the direction given it on the start. The apparatus was planned by Obry of the Whitehead shops at Fiume, and is generally known by the name of the inventor. At first the motive power to keep the gyroscope in motion was a spring, but this proving irregular a little motor run by compressed air is now used. The original model of Obry had a minute dynamo.

Theoretically, it is merely necessary to aim the torpedo correctly to have it strike the target, but here there are practical difficulties, for both sender and receiver may be in motion, and there is besides the uncertainty that every hunter feels in the presence of game.

A very real improvement in the modern automobile torpedo is that the quantity of explosives has constantly been increased. From the earliest model with about 32 pounds to those in use to-day, which have as much as 300 pounds of gun-cotton, the step is a long one, and the present missile is capable of causing great destruction in the hulls of even the best protected vessels.

It is interesting to note the different lines of development in the various powers of the world with reference to the torpedo.

In France the modifications have led to a type of 450

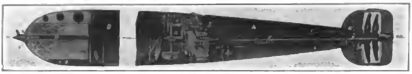

Fig. 4.—Section of Bliss-Leavitt torpedo.

P, percussion needle; *G*, safety pin; *C*, explosive; *D*, priming; *B*, compressed air tank; *K*, water valve; *H*, pendulum; *M*, motors; *SH*, air heater; *O*, plunge-motor controlling the depth of immersion; *V*, gyroscope; *T*, gyroscope spring; *GH*, plunge rudders; *FO*, rudder controls; *E*, shaft; *I*, propellers. The steering rudders are the little dark squares in the forward expansion of the tail.

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* Compiled from *La Nature* and *La Science et la Vie*.

millimeters with a charge of 108 kilogrammes of guncotton, the explosive force of which is four times that of gun-powder. The weight of the projectile is 2,000 pounds; the range, 9,000 meters, the early velocity 42 knots, which is maintained up to 2,000 meters, with the final velocity not less than 28 knots. The price of such a projectile is about $4,000. The new French armored ships are furnished with six torpedo tubes below the water-line and protected against direct shots, while the submarines now carry eight tubes.

England uses torpedoes of 533 millimeters caliber of the Armstrong & Hardcastle models, with an early speed of 45 knots and ability to maintain high speed, and the charge is 130 kilogrammes of explosive.

Germany places on board its armored ships a torpedo of 530 millimeters with 128 kilogrammes of explosive, while the cruisers and torpedo boats use another model of 500 millimeters, but with the shorter range of 4,000 meters. Studies have been made with torpedoes of 600 millimeters with great speed and range.

Russia is the only power besides France that has kept to the model of 450 millimeters, but with a heavier charge, 125 kilogrammes. The range of the Whiteheads it uses is greater than 6,000 meters.

In the United States the model adopted is the Bliss-Leavitt (see illustration) of 533 millimeters diameter with 128 kilogrammes charge, capable of making 36 knots at 1,000 meters and 30 knots at 4,000 meters. Experiments have been made with others of the projectiles with effective distances up to 9,500 meters.

As to modern tactics with these terrible weapons, it consists no longer of isolated shots, but in volley fires. Such a discharge of a number of torpedoes against a line of ships is considered as sure of results. The torpedo boats under such circumstances will have some advantages, for after the first phases of a naval combat a certain amount of confusion is likely to be produced by some of the vessels showing signs of weakness, and then they can charge the fleet in a body. This may take them to within 2,000 or 3,000 meters of the enemy, and without doubt they can from there send out torpedoes that will be pretty certain to hit.

It is generally estimated that at 4,000 meters 30 per cent of the torpedoes will be effective. If this were only ten per cent, and out of 40 projectiles 4 explode and put out of the battle two or three vessels, the attacking fleet will have achieved enormous results.

Torpedoes have the general form of a cigar, being about 5 to 6 meters in length with a diameter of about 450 millimeters. The body is of steel, and consists of four sections firmly screwed together. The head, about one eighth of the whole length, is conical in form, and within it is the explosive furnished with the percussion apparatus, which, when the projectile strikes an obstacle, ignites the priming and causes the explosion. Behind this is the second section with the air reservoir, a steel cylinder containing compressed air for the motors and machinery. The third section may be called the engine room, where there are the various devices for propulsion, steering—both laterally and vertically—etc., and behind this a combination of shaft-room and rudder runs. There are two propeller shafts, one within the other, each with its own screw. The propellers are in a kind of cage of square frames, the pattern of which varies in the different torpedoes, which furnish bearings for the propellers and supports for the rudders.

The Atlas of Finland[*]

A Model Geographical Work of a Little Known but Interesting Country

Review by Gustave Regelsperger

[*The beautiful work, of which the French edition bears the title "Atlas de Finlande, 1910," was published at Helsingfors, in 1911, by the Society of Geography of Finland. It is a statistical atlas of very wide scope, its nearest American parallel being the "Statistical Atlas of the United States," which our Bureau of the Census issues periodically, and of which a new edition will probably appear during the present autumn. There are, however, important differences between these two works, as to scope and treatment. The Finnish atlas, with its two accompanying volumes of text, is, in fact, unique as a complete compendium of the geography of a country, using the term "geography" in its broadest sense. In scholarship and workmanship it is hardly surpassed in the whole range of geographical literature.*—Editor.]

Lying between Sweden and Russia, Finland pertains geographically and geologically to the former. In the north it is in no way distinguished from Sweden, whose dense forests are continued across the border. In the south it consists of a lacustrine plateau, resembling that of Småland, which, on the other side of the Baltic, forms the southern extremity of Sweden; both are covered by a complicated network of lakes and interconnecting water-courses. In spite of its affinities with Sweden, however, Finland well deserves to be studied as a separate geographical unit, in view of its pronounced topographic features, its position between Sweden and Russia, and its outline, in virtue of which it forms a large peninsula between the Gulf of Bothnia on the one hand and the Gulf of Finland, prolonged by Lake Ladoga, on the other. Finland may, in fact, be considered as forming in certain respects a transition between the two countries which border it. It lacks the high mountains of Sweden, its relief not surpassing that of the eastern coast of the Scandinavian peninsula, so that we may regard it as a step leading from the high terraces of Sweden to the marshes of the Baltic provinces of Russia and the plains stretching thence to the Ural and the Caucasus.

However, the individuality of Finland as a country is due in even larger measure to its population; the Finns, who are greatly in the majority, being a totally different race from those which inhabit the neighboring countries. On account of their position, the Finns have necessarily been subject to attacks and invasions on the part of the Swedes and the Russians, and the history of Finland is made up chiefly of these struggles. Though generally preserving more or less autonomy, Finland has never been entirely independent. For centuries it was ruled by Sweden, and it is now a part of Russia. Yet, as the home of the Finnish people, with only a small Swedish element, and a still smaller Russian, it has withstood the efforts of Russia to assimilate it to herself, and preserves unmistakably the germs of an independent national existence. Impelled on the one hand by the patriotic idea of making the Finnish people better acquainted with their country and with themselves, and on the other hand by an ambition to contribute to the general fund of geographical knowledge, the Society of Geography of Finland determined to present a detailed record of both the physical and the human geography of this interesting land, and in the fulfillment of this determination has produced a work of the highest rank.

The first edition of the atlas appeared in 1899, and was the development of material presented by the society at the Sixth International Geographical Congress, held in London in 1895. The edition now under review bears imprint 1911. The committee responsible for its production had at its head Colonel and ex-Governor Max Alfthan, who was a member of the committee which compiled the earlier edition, and three other members of the same committee, viz., J. A. Palmén, secretary of the society; Prof. J. J. Sederholm, director of the Geological Commission; and E. G. Palmén, professor of Scandinavian and Finnish history at the University of Helsingfors; also two new members, viz., Mr. Onni Olila, chief of the Cartographic Bureau of the government survey; and Dr. K. R. von Willebrand, chief engineer in the Department of Roads and Bridges. As compared with the 32 sheets of the first edition, the second contains 55; while the text, which also contains numerous charts, illustrations, and graphs, has more than tripled. The atlas volume is issued in a single edition, with titles and explanations in Finnish, Swedish and French; while of the two text volumes there is a separate edition for each of these three languages. The French translation is by Prof. J. Poirot, of Helsingfors. The atlas is divided into two parts, to each of which corresponds one of the volumes of text; the first devoted to the physical geography of the country, the second to its human aspects.

I. PHYSICAL GEOGRAPHY.

In his exposition of Chart I—the general map of Finland—Mr. Olila traces the history of Finnish cartography. The earliest charts date from the fifteenth and sixteenth centuries. That of Olaus Magnus (1539) is noted as having been the first to give a tolerably correct idea of the configuration of the country as a whole, and its position with respect to the adjoining countries. The earliest productions of serious merit, however, appeared in the fore-part of the seventeenth century, and were issued under the auspices of Charles IX., of Sweden. One by Andreas Bureus (1626), reproduced in the present atlas, was a remarkable work for its time, though it shows a non-existent chain of mountains running through the middle of the country. In the eighteenth century new surveys were made, in connection with the division of lands and the fixing of taxes, and these led to the excellent series of charts published from 1797 to 1807 under the auspices of Baron Hermelin. Parish charts on a uniform scale (1 to 20,000) were issued by the government survey department between 1840 and 1850, as well as charts of districts, based upon these, on a scale of 1 to 100,000. A general map of Finland in 30 sheets, based on a network of points fixed astronomically, was issued by the government in 1863-72. Only two extensive geodetic surveys were, however, made in Finland during the nineteenth century; viz., that of the Russo-Scandinavian meridian, extending from the mouth of the Danube to the Arctic Ocean, executed from 1816 to 1855, which crossed Finland; and the Baltic triangulation made from 1828 to 1838 by the Russian authorities, under the direction of General Schubert.

The general chart published in the atlas on a scale of 1 to 2,000,000 was drawn up by the society itself, with the use of all available material, and is based upon about 500 accurately determined positions. The same chart, with or without reduction, is used as a base-map for the other charts of the atlas.

Chart 1 shows the political subdivisions and the hydrography, but not the relief. Chart 11 is hypsometric. From this chart it is evident that no part of Finland is truly mountainous except the extreme northwest corner, which projects deep into the Scandinavian peninsula, to which geographically it belongs. In fact, the culminating point of Finland, Halditschokko, which attains only 4,440 feet, lies on the frontier. Aside from this small northwestern region, Finland is a very hilly but not a mountainous country. Seen from a balloon it would appear remarkably flat, but it really comprises innumerable small irregularities. Over the greater part of its surface the altitude varies between 300 and 1,300 feet above sea-level.

Throughout Finland there is an extraordinary abundance of water. Including the Finnish portion of Lake Ladoga, 11.73 per cent of the entire surface of the country is made up of lakes and streams. In the south, especially, the lakes are innumerable, while bogs and marshes are found everywhere. Southern Finland, which presents the most characteristic landscapes of the country, has been called "the land of a thousand lakes"—but "tens of thousands" would be a more accurate description. Chart 12 of the atlas, showing this lacustrine plateau, presents a truly fantastic appearance. This chart alone includes 9,000 lakes; while a chart of all Finland, on a scale of 1 to 400,000, includes no less than 35,500. The surface of the country may be compared to a sponge full of water which has been stretched out from southeast to northwest, as nearly all the water-courses and the majority of the lakes trend in that direction.

The shores of these lakes are extremely cut up with bays and inlets, and their bottoms are extremely uneven, and rarely of much depth. Chains of lakes are very common. The streams which drain the various lake basins are interspersed with rapids, generally of moderate gradient. Chart 14 shows the location of these rapids, and the water-power which each is capable of furnishing at low stage.

The peculiar hydrography of Finland is explained by its geological history. The atlas treats the geology of the country historically. Chart 3 shows the prequaternary rocks, and Chart 4 the quaternary deposits; while several additional charts, on a smaller scale, deal with the history of the whole Fenno-Scandinavian region, showing the progress and effects of quaternary glaciation, and the fracture lines due to violent earthquakes in the tertiary period.

The soil of Finland consists chiefly of hard crystalline rocks—granites, gneiss and schistes—formed at a very early period. A coarse red granite known as *rapakivi* is characteristic of the country. The commonest sedimentary rocks of this region are pre-Cambrian. These earlier formations show marked folding, the folds running from southeast to northwest, and this direction was subsequently followed by the glaciers. Hence the curious appearance of the lacustrine plateau, which looks as if an immense harrow had been drawn across it. Before the glacial period, however, the country had been fissured in all directions by violent upheavals and subsidences. The wonderful modern network of lakes is, therefore, due to the same combination of causes which produced the similar lacustrine landscapes of Sweden, Russian Karelia and Canada.

The same process which produced the Finnish lakes gave rise to the remarkable Aland and Abo archipelago, lying off the southwest extremity of the country. This consists of numerous large islands and a myriad of islets, rocks and shoals, spread like grains of dust over the chart (No. 10). It is aptly described by Prof. Sederholm as a submerged landscape of lakes, i. e., the same landscape that prevails over southern Finland extended out into the sea.

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[*] Abstracted from *Revue Générale des Sciences.*

An important series of charts deals with the hydrography of the adjacent seas, viz., the Gulf of Bothnia and the Gulf of Finland, showing the limits of ice, temperatures at various depths and at various seasons; maximum and minimum temperature at the bottom, salinity, oxygen content, surface currents, tides, color and transparence. There are also bathymetric charts of the Gulf of Finland and Lake Ladoga, showing both these bodies of water to be relatively shallow.

Four plates of the atlas (Nos. 16-19) consist of meteorological charts. The accompanying text, by Dr. O. V. Johansson, of the Central Meteorological Institute, includes a brief history of meteorological observations in Finland, dating back to the seventeenth century. The charts include, in addition to isotherms, isobars, isohyets, wind-roses, and other data of usual character, a chart showing the average date of first snowfall; charts of the depth of snow-cover in each winter month; and a chart of the depth of snow on March 25th, 1890, after a period of excessive snowfall. There is also a chart showing the average date on which the ice breaks up in the spring; while four charts relate to thunderstorms. Owing to the prevalence of west and southwest winds—i. e., moist, mild winds from the Atlantic—and to its moderate altitude, Finland has not a rigorous climate. Cloudiness is excessive, but the rainfall comparatively light.

Several charts dealing with the flora and fauna conclude the part of the atlas devoted to physical geography. Finland is well covered with forests, but the true forest region is the northern half, which belongs to the wooded zone that characterizes the whole of northern Russia. The state forests (shown by a separate chart) are almost all in this zone. The greater part of the country lies within the great northern belt of conifers; but toward the north this is succeeded by a zone of birch, while in the extreme south Finland enters the oak region of central Europe.

In the treatment of the flora, the country is divided into 31 botanical provinces. The number of vascular species, indigenous or naturalized, is shown for each province, the total being about 2,182. Among these are 21 species of trees. The limits of cultivated plants of various species are shown on two charts; one devoted to the cereals; the other to potatoes, cabbage, clover, textiles, etc.

In the indigenous fauna of Finland there are recognized 61 species of fishes, 5 batrachians, 6 reptiles, 232 birds, and 54 mammals. The limits of certain species are shown by charts. It is noted that a part of the fauna is threatened with extinction by the advance of human settlement. This is especially brought out by charts showing the limits within which bears were shot during successive periods of years, and the relative number of lynxes shot in recent and in former times.

Other charts and their accompanying text give detailed information regarding fishes and fisheries, of both the seas and the inland waters. The Baltic, on account of its low salinity, is not rich in true marine fishes. Salt water and fresh water species are curiously mingled. The most abundant and economically important marine species is the Baltic herring (*Clupea*). The first volume of text concludes with a notice of the marine plankton, by Prof. Levander.

II. HUMAN GEOGRAPHY.

The studies of human geography embodied in the atlas are fully as important as those relating to physical geography, and are the fruit of a truly enormous amount of statistical material.

Trustworthy demographic data date back to 1750, at which period statistics of population began to be collected on a uniform plan by the clergy, under the auspices of the Academy of Sciences. The atlas includes graphs showing the progress of such data down to 1907, as well as numerous charts presenting conditions at the present time, or for other specified periods. The growth of population during 157 years has been fairly uniform, except that certain definite calamities—wars, epidemics, and famines—have left their traces conspicuously in the curves. During the period in question the population increased from 534,065 to 3,012,849. The chart showing the present density of population in each parish brings out the striking contrast between the well-populated coast regions and the very sparsely inhabited regions of the north. An even more striking chart (No. 26) shows how the population tends to cluster along the water-courses, around the lakes, and on the islands of the Abo Archipelago.

One of the most instructive charts, with its accompanying text, presents statistics of emigration (most of which is to the United States). The mean annual number of emigrants per 10,000 inhabitants, during the period 1893-1907, is shown for each parish in the southern half of the country, and is seen to have been far greatest from the Österbotten coast region; especially from the governments of Uleaborg and Vasa. The total annual emigration during the above period has varied from 10,000 to 20,000. Unhappily for the country, three quarters of the emigrants are drawn from the agricultural population. Prior to 1880, emigration was very small.

As to the races in Finland, the Finns constitute 87 per cent of the population, and the Swedes barely 13 per cent. The latter are found chiefly in Aland and the adjacent archipelago, and in certain other littoral regions. In 1900, the language spoken by 2,352,990 persons was Finnish; while 349,733 spoke Swedish, 5,939 Russian, and 1,925 German. Far in the north is a small population of Lapps (1,515 in 1910). Gypsies are estimated to number 1,551. It is interesting to note the encroachments of the Finnish population upon regions formerly occupied by Swedes, as shown by the survival of Swedish place-names far in the interior, where the inhabitants are now all Finns.

The sanitary condition of the people is shown in considerable detail, with charts representing the distribution of specified diseases and defects. Pulmonary consumption causes great ravages in Finland, more especially along the western coast.

The economic life of the country is shown in a long series of striking and instructive charts, to which correspond the greater part of the memoirs in the second volume of text. These are so various that it is difficult to summarize them in a brief review. Two series of charts under this head deal with agriculture and manufactures, respectively. A number of ingeniously constructed graphs present a wealth of information concerning the foreign commerce of the country, and its fluctuations. Cereals and woven fabrics are the commonest objects of importation, while by far the most important exports are the products of the forests. The export trade in butter ranks second. Chart No. 40 shows the measures that have been taken to facilitate navigation in the difficult waters of the Gulfs of Bothnia and Finland, with their innumerable islands and intricate channels. This chart indicates the locations, kinds, and ranges of all the lighthouses on these shores, whether Finnish, Swedish, or Russian, as well as the lights on the large lakes; also the extent of the hydrographic surveys that have been carried out by the Finnish and the Russian authorities.

The inland communications of the country, by land and water, are shown in great detail. Finland is not only well supplied with roads (and in the south with railways), but it also possesses a system of water communications without rival in Europe. It has 4,000 miles of telegraph lines, and 58,400 of telephone.

The economic portion of the atlas concludes with charts relating to savings banks, the co-operative movement, and insurance. Then come charts dealing with political geography and one showing the distribution of schools and the school attendance. From these modern themes the atlas suddenly reverts to prehistoric times, with some admirable charts devoted to archæology. It is interesting to note that the remains of the stone age indicate a distribution of population in that period corresponding rather closely to that of to-day.

Last of all come charts, on a scale of 1 to 30,000, of the 38 principal towns of Finland. These range in population from Helsingfors, with 137,346 inhabitants, to Nadendal, with 903. In the text volume, the history of these towns is given in detail.

Though only a hasty sketch, the foregoing review will perhaps suffice to give an idea of the extent and variety of the material embraced in the Atlas of Finland and the two volumes of text that accompany it. The Society of Geography of Finland has furnished a striking example of what should be understood as comprising the geographical study of a country. From environing physical conditions spring, necessarily, the development and characteristics of a people; there is no physical geography without a human geography, nor can one be studied without the other. They are merely two points of view, so interrelated as to be inseparable.

The geographical work undertaken by the Finnish society in accordance with this idea has been so perfectly carried out, and represents such an amount of erudition and patient research, that it may well be held up as a model for all works of the same character that may be undertaken in other countries.

Substitutes for Automobile Gasoline[*]

By Gail Mersereau

During the last few years the development of the automobile and the greatly increased use of gasoline in chemical extraction work, combined with the partial exhaustion of the crude petroleums rich in gasoline, has more than doubled the cost of value of this product.

During the last year or two there has been a great demand for some cheaper substitute for use in the automobile engine. The publication in the daily papers of offers of prizes for a solution of the problem has spurred on inventors to work out many ingenious possible solutions.

Denatured alcohol can be used readily. It is clean, not so dangerous as gasoline, and will give three fourths as much mileage as gasoline per gallon (and sometimes better); but it costs much more than gasoline, and it hardly seems probable that the price will decrease greatly in the future.

Kerosene has been used and is being used more and more in heavy trucking. In order to use it in the ordinary motor it is simply necessary to heat the carbureter by means of the exhaust gases. The motor must be started with gasoline or alcohol. There is no difficulty in this, as it is easy to attach a small supplementary tank.

The great drawback to the use of kerosene is its production of polymerized products in the cylinder and the formation of coke and lampblack from these products. This polymerization reaction takes place apparently only in the larger globules of the kerosene which enter the cylinder. The outside layer of oil is partially oxidized, with the formation of high boiling polymers. These then condense on the relatively cool sides of the cylinder. Further explosions in the cylinder oxidize and burn off more of the hydrogen atoms until the material becomes nearly pure carbon.

Alcohol, injected into the cylinders, while still hot, at the end of the day's work, will clean out the greater proportion of these troublesome products. This is too much trouble for the ordinary automobile owner.

To obviate the difficulties above mentioned, namely, the preheating of the carbureter and the production of coke and lampblack, a great many mixtures have been proposed.

All kinds of low boiling point constituents have been added, so that the carburetter need not be preheated, and all kinds of oxygen containing materials have been added to prevent the dehydrogenation and polymerization of the molecule.

Many mixtures of kerosene with acetone, other ketones, alcohol, casing-head gasoline, methyl, and ethyl ether, etc., have been proposed and tried. Many of these mixtures work very well, but the average owner wants a fuel that can be purchased at any point on his travels.

The Southey carbureter[1] or rather "gasifier" seems to work very satisfactorily. In this apparatus the kerosene is sprayed into a chamber, where the spray comes into contact with a small amount of air. A partial combustion takes place, just enough air being admitted to cause sufficient combustion to furnish the heat necessary to gasify the oil. This combustion is started by a spark, but after a minute or two the spark may be cut off. The chamber is so arranged that the large globules of oil from the spray drop to the bottom and are returned to the main tank.

The apparatus works very well in practice. It gives practically no trouble from coking or the formation of evil-smelling products of partial combustion. Kerosene of very much the same composition can be bought all over the world. This seems to solve the problem.

Many methods[2] for the manufacture of gasoline from heavy oils have been proposed and quite a number patented. The principle on which most of these work is the distillation of the heavy oil under pressure. The first lot of these gasolines to reach the New York market a year or so ago, were straw-colored, ill-smelling oils. They had been distilled carelessly and contained considerable proportions of very heavy oils, but during the last few months the quality has been much improved. These gasolines made by high pressure distillation are now being manufactured on a very large scale in this country, but the price is maintained very close to that of the natural petroleum product.

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[*] *Journal of the Society of Chemical Industry.*

[1] Southey, Eng. Pat. 27,612, December 9th, 1911.

[2] For example, Burton, U. S. Pat. 1,049,667, January 7th, 1913; Leffer, Eng. Pat. 2,328, January 29th, 1912.

Peppermint Oil in the Ukraine

The Ukraine is an almost unknown part of the world, but nevertheless a vast, very fertile, and beautiful country; it consists of that portion of Southern Russia known as "Little Russia," together with Ruthenia, which embraces the Austrian provinces of Galicia and Bukovina. A sample of the peppermint oil grown in this locality has been examined and found to have the following characters: Specific gravity, 0.904; optical rotation, —26 degrees; total menthol, 53.8 per cent; esters as menthyl acetate, 6 per cent. It is soluble 1 in 3 volumes of 70 per cent alcohol, becoming slightly opalescent with 10 volumes. The rich black soil of the region and the beautiful climate are most favorable to the cultivation of essential oil-bearing plants. A tobacco grown there, "suitably flavored with peppermint," is universally smoked and enjoyed by the natives.

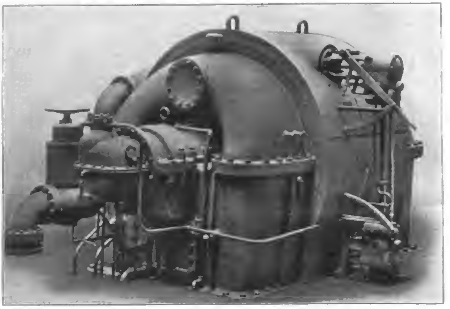

Fig. 1.—Oil relays for opening ahead and astern nozzle valves.

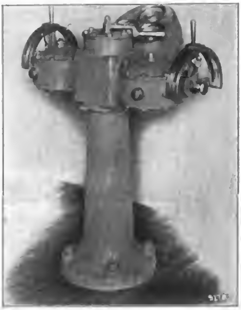

Fig. 2.—Bridge control stand.

The Westinghouse System of Bridge Control[*]

Apparatus for Controlling a Turbine-Driven Ship from the Bridge

One of the most interesting features of the marine turbine drive developed by the Westinghouse Machine Company, which involves the use of high-speed turbines with a floating frame reduction gear interposed between the turbine and the propeller shaft, is the method by which the turbines can be controlled by the navigator on the bridge as well as by the engineer from the starting platform.

After several months' service on the United States collier "Neptune," where this system was first installed, the method of bridge control was found to be thoroughly reliable and of distinct advantage in the operation and maneuvering of a ship in an open seaway and in going alongside a dock. Indicators show the navigator on the bridge just what the turbines are set to do and just what they are doing at every instant, while gages show the air and steam pressures available, so that the action of the propellers is always directly under the control of the officer who is handling the vessel.

The medium used for transmitting to the engine room the movements of the control handle on the bridge is air, while the medium used for the actual operation of the relays moving the steam valve is oil.

DETAILS OF THE CONTROL SYSTEM.

A diagrammatic arrangement of the operating parts of the control system, including the bridge control and steam nozzle valves, is shown in Fig. 3. As will be seen from examining the left-hand part of the illustration, the bridge control lever D' is movable in two quadrants A' and C', with an offset B' parallel to the axis of movement.

When the control lever D' is at B' both the ahead and astern nozzles are closed. The operating handle D' turns a shaft carrying a cam E', which has pressed against it the point of a small valve F'. The valve F' is hollow and closed at both ends, and has two sets of ports, G' and H', the former always being in communication with the source of high-pressure air supply (furnished by a standard Westinghouse air brake compressor), and the latter having its edge to the extreme left, just line in line with the ports I' in the piston L'. The end of the plunger valve F' is line in line with the left-hand edge of the ports I'. A small spring K' within the piston L' is provided to maintain a positive contact between the point of the plunger F' and the cam E', thus fixing the position of the plunger F' by its point of contact with the cam E'. The movement of the piston L' to the left is resisted by the spring N'. The space J', to the right of the piston L', communicates with space Q' between two diaphragms R' R', and the space to the left of the piston L' communicates with the atmosphere. A communication to the passage within the piston L' to atmosphere is provided by the ports M'.

The diaphragms R' R' control two valves, T' and U', the former controlling an opening to atmosphere and the latter an opening to the source of high-pressure air supply. The spaces S' S' are connected by a passage, so that the pressure in them is always equal. The space S' communicates either with the ahead or the astern operating relay in the engine room.

The function of the bridge control valve just described is simply to maintain a predetermined constant pressure in the air relay cylinder, and this is accomplished as follows with the apparatus just described.

OPERATION.

When the lever D' is moved from its central position B' in the ahead quadrant A' the cam E' pushes the valve F' to the left, thereby bringing the port H' into communication with the port I' in the piston L'. This admits high-pressure air into the space J', and consequently Q'. As the pressure in the space J' increases, it will quickly force the piston L' to the left, until the right-hand edge of the port I' cuts off communication with the port H', or should there be leakage, it will take a position such that the opening through the ports H' and I' would be just large enough to pass sufficient air to make up for the leakage and maintain a constant pressure in the space J'.

Since, normally, the spaces S' S' are at atmospheric pressure, when the pressure between them in the space Q' is increased, the diaphragms are forced outward, closing the valve T' and opening the valve U', thus admitting high-pressure air into the spaces S' S' until the pressure in the latter is equalized with the pressure in the space Q', thus bringing the diaphragms back to their normal position, permitting the valve U' to seat and thus cut off the supply of high-pressure air. The pressure existing in the space S' is transmitted to the space P' to the left of the air relay cylinder in the engine room.

As in the case with the piston L' and the ports I' and H', should there be leakage in the piping system communicating with the space S', the diaphragms R' R' will be distended slightly, thus holding the valve U' open sufficiently to make up the leakage and maintain constant pressure. Conversely, it is evident that if the pressure in the space J' should increase above that predetermined for a given position of the piston F', the piston L' will move to the left, and open communication between the space J' and the inside of the piston L', thus exhausting air from the space J' to atmosphere through the port U'. This condition also arises when operating lever D' is moved toward the off or central position, which permits the movement of the valve F' to the right. In the latter case the pressure in the space Q' will be decreased and become less than the pressure in the space S' S', causing the diaphragms R' R' to collapse and open the valve T' to atmosphere until the pressure in the space S' S' is decreased to that in the space Q'.

When the control lever D' is to be moved to the astern position, it is necessary to move it in the direction of its axis of rotation in the slot B'. When this is done an arm W' held between two collars on the cam shaft, moves the small slide valve X' to the right, and brings the pipe Z' to the astern air relay cylinder into communication with space S', and the pipe Z'' into communication with the atmospheric exhaust.

From the above it will be seen that it is impossible for the operator to become confused and accidentally move the control lever in the wrong direction, or try to put it in both the ahead and astern position at the same time, as it is necessary to move the controlling lever sideways before it can be moved from one position to the other.

THE GOVERNOR.

The governor, which controls the speed of rotation of the turbine shaft, is shown on the right of the diagrammatic sketch, Fig. 3. As will be seen, it is of the common fly-ball type, and is driven through the turbine shaft by a worm E and wheel D. The only movable part of the governor is the hollow spindle B, having the ports N and H in it. The movement of the spindle B is restricted by a diaphragm K, to which it is attached. The upper side of the diaphragm is open to atmosphere, and the space below G is filled with oil.

High-pressure oil at about 65 pounds gage per square inch is admitted to the revolving spindle B through the ports A.

When the governor spindle is revolved by the turbine shaft the balls MM are thrown outward by centrifugal force, thus pulling the spindle B downward against the resistance of the diaphragm K, opening communication through the port H in the spindle, and I in the upper spindle bushing, to the space G, the latter communicating through a port L to a pipe connected to the space N of the air cylinder relay.

As the pressure in the space G, below the diaphragm K, increases, it resists the downward thrust of the spindle B, due to the centrifugal action on the governor weights until the upward pressure on the diaphragm exactly balances the downward thrust of the spindle, thus permitting the upward movement of the spindle B by the elasticity of the diaphragm K until the communication through the ports H and I is cut off. Thus it is evident that for any given number of revolutions of the governor spindle there must be a constant fixed pressure of equilibrium in the space G below the diaphragm. Should the pressure in the space G exceed that corresponding to the speed of rotation of the governor at any instant, the spindle B will be forced upward, thus opening communication between the space G and the atmosphere through the ports N in the governor spindle body.

AIR RELAYS.

In the center part of the diagrammatic sketch is shown the air relay cylinder, relay valve and operating cylinder, which control the opening and closing of the nozzles of the turbine according to the speed of rotation desired. Referring to this part of the illustration, and starting with the turbine at rest, the piston *Y*, which opens and closes the nozzle valves is at the farthest end of its travel to the right, and all the turbine nozzles are closed. When air from the bridge control valve is admitted to the space *P*, to the left of the air-operating cylinder, the piston *Q* will be forced to the right against the resistance of a small spring, thus carrying the relay plunger *O* with it. The movement of the latter establishes communication between the space *R*, supplied with high-pressure oil, and the space *X*, to the right of the piston *Y*; and the space *W*, to the left of the piston *Y*, is brought into communication with the space *T*, and thereby with the oil return to the reservoir, which is open to atmosphere. Thus the piston *Y* will be forced to the left by the oil pressure and through a rack engaging with the gear cut in the periphery of the nozzle valve, will rotate the latter and open the high-pressure nozzles, thus admitting steam to the turbine. As there is nothing to resist the motion of the piston *Y*, nozzles in excess of those necessary to give the desired speed are opened instantaneously and thus the turbine begins to speed up very rapidly. Now, however, as the turbine gains speed and the governor revolves, the governor spindle *B* is forced down and high-pressure oil is admitted through the ports *H* and *I* and through the passage *L* to the space *N* to the right of the piston *Q*, thus tending to push it to the left against the air pressure in the space *P*. As the piston *Q* moves to the left it carries the relay plunger *O* with it, and when the oil pressure in the space *N* balances the air pressure in the space *P*, or, in other words, the space *J'* in the bridge control valve, the piston *Q* will take a fixed position, and the piston *Y* will take up a position such that the ports communicating with *W* and *X* are both closed, thus maintaining a constant speed of revolution.

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[*] From *International Marine Engineering.*

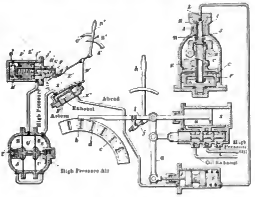

Fig. 3.—Diagrammatic arrangement of bridge control and nozzle valves.

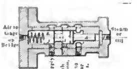

Fig. 4.—Relay valve controlling compressed air in dilating coils.

Should the turbine tend to exceed the speed fixed by the air pressure in the space *P*, the piston *Q* would move to the left and bring the space *X* into communication with the space *S*, connected to the oil exhaust, and the space *W* would be brought into communication with the space *R*, supplied with high-pressure oil. This would cause the piston *Y* to move to the right until sufficient nozzles had been shut off to reduce the speed, until the oil pressure in the space *N* was again brought into equilibrium with the air pressure in the space *P*.

"CUT-OUT" VALVE.

The bridge operating stand which supports the bridge control valves is shown in Fig. 2, from which it will be seen that there is a rotary slide valve on top of the stand between the port and starboard control valves. This latter valve is not shown in the diagrammatic sketch previously described, and is not shown in detail because of the difficulty of showing the various ports in it. Its function, however, is to permit operating both turbines, either ahead or astern, by either the port or starboard control valve, or to cut out both the starboard and port control valves. In addition to these functions which this valve performs on the bridge control stand, the similar valve on the control stand in the engine room has a position for cutting out the bridge stand and other operating stands in other portions of the ship. Thus when the control system on the bridge is connected, all control stands excepting that in the engine room are made inactive, while if the stand in the engine room is being used all other stands (including the one on the bridge) are disconnected. This arrangement avoids interference, permits rapid changes from one station to another, but always leaves the engine room stand operative in case of an emergency.

Ordinarily, except when maneuvering, the bridge stand is always connected up so that both turbines are controlled by moving either the port or starboard control levers, which simplifies the operation and permits controlling both turbines if either the port or starboard operating valves should for any reason become temporarily disarranged.

In addition to the standard screw-down valves on the ahead and astern turbines, each turbine is provided with a hand-operating device, by means of which a nozzle valve can be moved by hand, if necessary or desirable.

This is accomplished by the lever *h*, as shown in the diagrammatic sketch, Fig. 3. The lever is pivoted on the shaft *j*, and has a lever engaging with the crosshead on the valve-operating piston rod *l*. The latter lever is fitted with a latch so that it can be quickly connected or disconnected when not in use.

As previously pointed out, there may be a number of operating stations from which the turbines can be controlled when this is desirable, as, for instance, there might be considerable advantage in the case of battleships in having the turbines controlled from the central station as well as from the bridge and starting platform.

GAGES AND INDICATORS.

In order that the officer on the bridge or navigator can see that the turbines are operating as desired, and also to show that the control system is in operating condition, gages are provided which show the steam pressure in the boilers, the air pressure in the control system, the air pressure in the pipe lines *Z' Z''*, as well as the pressure in the oil supply system, and the pressure of the oil under the pistons of the floating frame on the reduction gears.

As it would be frequently necessary to have the piping communicating from the engine room to the bridge in exposed places where it would be liable to freeze, and because of the difficulty of allowing for the hydrostatic head in the pipe between the bridge and the engine room in the case of liquids, the steam and oil pressures are indicated on the bridge by means of compressed air and a small relay valve, such as illustrated in Fig. 4. As the steam pressure or oil pressure to be indicated on the bridge may exceed the air pressure available, the former are reduced in some ratio, such as 2 to 1 or 3 to 1, as required.

In Fig. 4 the orifice *B* is connected to the steam or oil line, and the pressure desired is indicated on the bridge by the air pressure in the pipe connection to *F*, which communicates with the gage on the bridge. The operating element of the relay consists of the plunger *LA*, having *L* and *A* the same diameter, or *A* a smaller diameter than *L*, for relaying oil or steam pressures. The plunger *LA* is fitted in a bushing, having ports *G* and *H*, port *G* communicating with the high-pressure air supply and port *H* communicating with atmosphere. A drain *C* is also provided, which may either drain to the bilge or to the oil reservoir when oil pressure is being relayed.

Normally, when not being used, the small spring pushes the plunger *LA* to the right, and the gage on the bridge is then connected to atmosphere through the ports *K* and *H*. When steam or oil under pressure is admitted at *B*, the plunger *LA* is forced to the left against the resistance of the spring, and the edge *J* of the plunger *LA* moves over the port *G* and admits high-pressure air through the port *K* to the gage on the bridge, the pressure in the space to the left of the plunger *LA* increases, until the pressure times the area of the left-hand portion of the plunger *LA* equals the pressure times the area on the right-hand portion of the plunger *LA*; thus if the diameter of plunger *L* is twice the diameter *A*, the area of the large end of the plunger will be four times that of the small end, and the actual pressure maintained on the left-hand side of the plunger will be one fourth of that maintained on the right-hand side of the plunger, thus 200 pounds gage steam pressure would be indicated on the bridge by 50 pounds of air pressure. The oil pressures are transmitted to the bridge in the same way.

SPEED INDICATORS.

As was pointed out in describing the operation of the controlling system, there is a fixed pressure (for any given number of revolutions per minute of the turbine shaft) in the spaces *Q'* and *S' S'*, as well as under the diaphragm *K* in the governor spindle and the space *N* to the right of the air-operating cylinder. Consequently, instead of graduating the gage recording the air pressure in the space *S'* in pounds, this scale may conveniently be graduated to read revolutions per minute, so that those in charge on the bridge can see every instant exactly the number of revolutions which the propellers are making.

Another novel feature of the new control apparatus used on the U. S. "Neptune" is a set of speed recording instruments. As previously mentioned, for any given turbine speed there will be a definite oil pressure under the diaphragm *K* of the governor, and consequently this pressure can be used to indicate the speed of the turbine and propeller.

Pressure gages of the recording type may be used, showing the speed, direction of rotation, and period of operation of each turbine under any given conditions. These records furnish an accurate log which is indisputable in case of a controversy regarding the speed or manner in which the turbines were operated. These cards can be graduated to read revolutions or knots, as desired.

Hardness of Metals

IN the *Int. Zeitschrift Metallographie* J. H. Andrews summarizes the views of Edwards and Grenet on this subject and points out that in several respects the ideas are opposed. Brinell hardness tests on quenched and slowly cooled Cu-Al and Cu-Sn alloys showed that quenching actually softens some of the alloys. This proves that Edwards's theory stating that "any alloy retained as a homogeneous solution which would otherwise consist of two constituents is thereby rendered much harder," does not hold good in all cases. Consideration is then given to the particular case of iron-carbon alloys which differ from the Cu-Al alloys under discussion in that the phases separating at 700 deg. Cent. are a pure metal (ferrite) and a pure metallic compound (cementite), while in the Cu-Al alloys the phases separating at 570 deg. Cent. are two homogeneous solid solutions. Further, one of the constituents separating from the iron-carbon alloys at the inversion point, undergoes an allotropic change at the same temperature. In the light of Benedicks's theory austenite consists of a solid solution of carbon or carbide of iron in γ-iron, while martensite is a solid solution of carbon or cementite in a solution of α- and γ-irons. The author believes martensite to be made up of free cementite embedded in a matrix of undecomposed austenite and α-iron the latter accounting for the magnetic properties of hardened steel, while the hardness is due to the combined effect of the solid solution and the carbide. Alloys of iron and carbon do not appear to fall into line with the non-ferrous alloys in any generalization on the property of hardness.

New Uses for Infusorial Earth

INFUSORIAL earth is being mined more actively in California and Nevada, which produced nearly 90 per cent of the 6,582 tons output last year in the United States. The value, according to a recent daily consular and trade report, averages $10.30 per ton. Heretofore diatomaceous or infusorial earth has been largely used as an abrasive in the form of polishing powders and scouring soaps, but the United States Geological Survey finds that of late its uses have been considerably extended. Because of its porous nature it has been used in the manufacture of dynamite as a holder of nitroglycerine, but so far as known not in the United States. Its porosity also renders it a non-conductor of heat, and this quality in connection with its lightness has extended its use as an insulating packing material for safes, steam pipes, and boilers, and as a fireproof building material. In this country a new use of the material is reported in the manufacture of records for talking machines. For this purpose it is boiled with shellac, and the resulting product has the necessary hardness to give good results. In Europe, especially in Germany, infusorial earth has lately found extended application. It has been used in preparing artificial fertilizers, especially in the absorption of liquid manures; in the manufacture of water glass, of various cements, of glazing for tiles, of artificial stone, of ultramarine and various pigments; of aniline and alizarine colors; of paper, sealing wax, fireworks, gutta-percha objects, Swedish matches, solidified bromine, scouring powders, papier-maché, and many other articles. There is a large and steadily growing demand for it.—*The Chemical News.*

Wireless Equipment on Aircraft*

By Marcus D. Manton

THE WORKING PRINCIPLE.

Perhaps a few words relating to how radiotelegraphy works would not be out of place. Wireless telegraphy signals are transmitted from one station to other stations by means of a series of waves which are set up in a wire or system of wires (which is insulated from all objects in contact with the ground) by means of electric oscillations. The system of wires employed is known as an aerial or as antennæ.

These electric oscillations in the aerial create a disturbance in the surrounding ether, and the message goes forth by means of electro-magnetic waves in the ether, in a somewhat similar way to the ripples created by dropping a stone into a pool of water. Ether may be defined as a rarefied element, all-pervading and intangible; it is also by means of these ether waves that light reaches the earth.

The energy creating these waves is simply an electric current which surges back and forward from end to end of the aerial, this change of direction taking place many thousands of times per second, and is what is commonly known as an alternating current. Whenever an operator presses a key, an oscillating current is supplied to the aerial; this sets up waves which go out into the ether and travel along in all directions until they come into contact with other aerials (the waves do not stop when they reach aerials, but pass along until they gradually damp themselves out), and in these aerials set up corresponding oscillations, which are made audible to operators at these stations by means of a detector and telephone receivers (there are many types of detectors in use, but these are too numerous to describe here)—see Fig. 1.

The current which produces the necessary oscillations in the aerial is generated by an alternator driven by an engine or motor of some kind or by means of an electric battery and induction coil (trembler, spark coil somewhat similar to the coils used for the ignition on automobiles).

Up to the present, and in fact even now, great difficulty is experienced in receiving wireless telegraph messages in an aeroplane; the waves reach the receiving aerial thereon, but the noise of the engine is so terrific that it makes the faint signals in the telephone receivers inaudible.

True, there are other ways of recording these signals—by means of Morse inkers, syphon recorders, etc., but these instruments require more than the minute currents which are produced by the ether waves, coming in contact with the receiving aerial, to operate them, and it is therefore necessary to employ a relay, which is an instrument which will automatically switch on an electric battery and supply the current necessary for working the Morse writer or whatever instrument is employed. Again, a relay is practically useless if it is subjected to any vibration, so until the aeroplane is produced that is silent or vibrationless, the reception of wireless messages on aeroplanes will remain a very difficult problem.

In the case of the dirigible the matter is simplified, since it can be fitted up with a silence cabinet wherein the operator could work undisturbed by the noise of the motors. And in any case the motors can be far more easily silenced than on aeroplanes.

TRANSMITTING WIRELESS MESSAGES FROM AIRCRAFT.

Though not without difficulties, transmitting wireless messages from aircraft is a good deal simpler than receiving messages, since the noise and other disturbing factors in this case are of no consequence.

The apparatus required to make this wireless transmission possible is as follows:

An alternator and transformer, the alternator being driven by the engine used for propelling the machine, or by means of an auxiliary engine or motor of some description, or in place of this alternator and transformer an induction coil may be used, the electric current being supplied to it from a battery of accumulators.

One of the two above-mentioned devices is necessary to supply the transmitting aerial or antennæ with energy, and in order to produce the necessary oscillations in the aerial a spark gap must also be provided (Fig. 2). A spark gap in its most simple form consists of two adjustable metallic knobs supported by pillars of a highly insulating substance; these pillars in turn being fixed to a base made of some non-conducting material. The spark knobs are mounted on brass rods and are arranged so that by pushing the rods inward or pulling them outward the distance between the spark knobs can be varied at will, until the most efficient distance between the knobs is found. This distance is known as the gap.

A key is also necessary to enable the operator to make and break the electric circuit at will, in order to produce dots and dashes for transmitting a message in the Morse or other prearranged code.

A transmitting set in its simplest form is shown in Fig. 3.

It will be noticed in the diagram that a ground connection is also made, in addition to one to the aerial or antennæ; and as it is impracticable to trail a wire from an aircraft to the ground, some other system must be adopted. This difficulty is surmounted by using a counter-poise which is a system of aerials similar to those devised by Lodge. It consists, in fact, of two distinct aerials, apart from one another and each highly insulated (Fig. 4). By this means a ground connection is not essential.

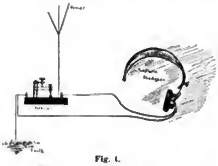

Fig. 1.

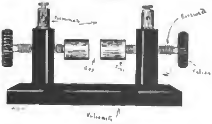

Fig. 2.

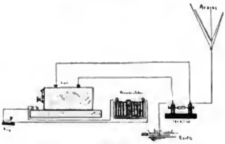

Fig. 3.

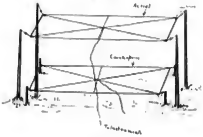

Fig. 4.

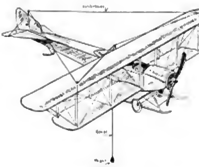

Fig. 5.

AERIALS ON AIRCRAFT.

These usually consist of a single copper cable about 60 to 100 yards long, one end of which is connected to the instruments; to the free end a weight is attached and then lowered over the side of the machine so that it hangs vertically below the machine when in flight. A winch is provided so that the aerial may be quickly wound up or down.

In the event of the machine having to make a forced landing and giving no time to wind up the aerial, the wire cable is severed by means of an aerial cutter which is fitted to the side of the winch, and the wire falls clear of the machine so that the aeroplane lands in the ordinary way without any danger of the aerial catching in trees or being tangled up by the propeller.

The counterpoise used in place of the ground connection consists of a system of wires running from the planes to the tail of an aeroplane or from end to end of the nacelle of a dirigible. Fig. 5 shows how a counterpoise and aerial are fitted to an aeroplane.

The object of this article is to try and explain in a non-technical manner the working principle of wireless telegraphy as applied to aircraft, and to show what a large field is open for inventors and experimenters.

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* Reproduced from *Aircraft*.

Turpidity of the Upper Atmosphere in 1912

Since the celebrated eruption of Krakatoa there has been no hesitation to attribute the darkening of the sky which occurs from time to time to volcanic eruptions, which sometimes becomes sufficiently serious to interfere with astronomical observations. The volcanic origin of these clouds of dust, which always float very high, has been verified so often that the observed turbidity of the upper atmosphere during the summer and autumn of 1912 has naturally been attributed to the violent eruption of Mount Katmai, in Alaska.

This view has been called in question by Dr. Barkow of the Filcher Antarctic Expedition, who observed a similar turbidity in latitude 70 degrees South in the middle of June, 1912, and for several months thereafter. He observed cirrus clouds at unusual altitudes and was able to read several hours daily by the light of the sky, although the sun was below the horizon, even at noon. In short, everything indicated the presence of reflecting particles at exceptional altitudes.

As it seems impossible that the dust of Katmai could have reached the Antarctic so soon after the eruption, Dr. Barkow concludes that the phenomena observed by him were caused by dust of cosmic origin, although this may have been reinforced, in the northern hemisphere, by volcanic dust from Mount Katmai.—From *Cosmos*.

Wireless Telegraph Station at the German Observatory at Spitzbergen

At this station a ½-kilowatt Telefunken apparatus is established, with a ship's antenna 20 meters high, by which communication can be had with the station at Green Harbor and thence to Europe. For fixing time, Green Harbor sent time signals, at first without confirmation from the observatory, by means of a chronometer checked by time signals from the Eiffel Tower. To receive time signals at the observatory the author erected an earth antenna 40 meters long in the direction of the azimuth of the sending station, and laid on the snow with which the ground was covered. With this primitive arrangement Green Harbor (135 kilometers) was continually heard, and Ingö (1,000 kilometers) occasionally. Later an earth antenna 230 meters long, and carried on insulating posts 1 meter high, was erected. Signals from Ingö were then regularly received.

The author says that it is generally well known that the strength of signals in the Arctic is subject to extraordinary variations, although the energy from the sending station remains constant. The variations seem to follow no law, but the sudden increase and decrease in the received energy is due to some as yet unexplained influence. Examples of these remarkable variations are given. The author experimented in order to receive the Paris and Norddeich time signals, and although these can be received quite well at Green Harbor with 4 ohms in parallel to 1,000 ohms, no results were obtained with the type of antenna previously described. Various types of antennæ were tried, but instead of improvement, signals were actually weakened. Satisfactory results were eventually obtained by two earth antennæ, whose free ends were connected to horizontal triangles. The clear tone of the Telefunken station at Norddeich is stated to be more suitable for reception with signals of varying strength than the growling note of Paris. It was rarely found possible to receive the complete series of time signals owing to the variations before alluded to.

An aeronautical apparatus was available at the observatory, balloon antennæ were experimented with, but the results were not strikingly better. By means of the direct time-signal reception from Paris it was found possible to determine very exactly the longitude at Ebeltofthaven.

The author emphasizes the usefulness of time signals to surveying expeditions, as very primitive and portable receiving apparatus can be employed.

Later experiments were made to see if transmission to Green Harbor was possible using the earth antennæ. No success was obtained, though a small receiving station 7 kilometers away and in a southwesterly direction from the observatory received signals. A balloon antenna was tried using the earth antenna as counter capacity, and communication with Green Harbor was effected, the antenna having a capacity of 500 centimeters and the antenna current being 5 amperes. A small ship-type antenna was finally erected, and the original type of earth antenna used as a counter capacity, satisfactory earth in the Arctic region not being easily obtained. With this antenna satisfactory communication was secured.

The paper is accompanied by a plan and elevation of the complete antenna system.

A Water Rheostat

In a communication to *Power*, P. M. Anderson tells how to build a water rheostat that is very simple in construction and can be put together quickly with ordinary material that can be picked up anywhere. The author claims that it is quite satisfactory, and gives the following description.

The drawing, Fig. 1, shows a 2,200-volt, single-phase or three-phase water rheostat constructed from material which is always available around a power plant. Two frames are constructed in the form of a T, to which 1¼-inch pipes are secured at the three ends, as shown. This triangle of pipes forms the electrodes, to which wires of any convenient size are attached by soldering or by means of screws. A 1-inch pipe is placed in the center of the triangle as a support and guide for the electrodes, and a ½-inch pipe is secured in the center of the bottom of any large barrel. This latter pipe fits inside of the first, so as to prevent the electrodes from swinging to the edges of the barrel. It is well to remove the top hoop, as it prevents the possibility of charring the ends of the staves. A hose bibb can be inserted near the bottom of the barrel for attaching a ¾-inch hose, or the hose can be dropped into the top of the barrel. The rheostat can be supported on blocks of wood or rest directly on the ground. Water can be allowed to overflow the top edges of the barrel or may be carried away through a pipe attached near the top.

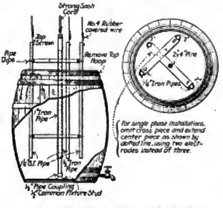


Fig. 1.—Details of construction of rheostat.

When the barrel is filled with water the electrodes can be easily adjusted to a level position so as to equalize the load on each phase. Any desired load within the capacity of the rheostat can be obtained by adjusting the depth of emersion. The capacity of such a rheostat depends on the quality and quantity of water available for cooling purposes. The chart in Fig. 2 shows a few capacity-emersion curves for different qualities and pressures of water. The form of the load curve depends upon the quantity, hence the pressure of cooling water and the angle or slope of the curve depends on the quality of the cooling water. The lower curve is the result of using slightly brackish cooling water.

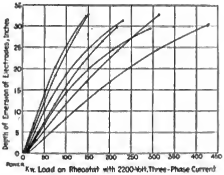


Fig. 2.—Capacity emersion curves.

The writer has used this type of rheostat extensively on 2,200 volts in various sections of the country. A rheostat constructed with a 56-gallon oil barrel and electrodes in a triangle 13 inches on centers will have a capacity of from 50 to 400 kilowatts. Mere contact of the electrodes with the water will produce a load of from 3 to 15 kilowatts. The capacity can be increased by reducing the size of the triangle or increasing the size of the electrodes, but in no case should the electrodes be less than eight inches on centers. With a steady flow of cooling water constant load can be maintained.

Correspondence

[*The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.*]

To the Editor of the Scientific American Supplement:

In Notes and Queries, No. 13007, W. C. P. gives "graphical solutions" for the formation of magic squares of the third and fourth orders. Working along this line I have constructed a number of designs for squares of these and higher orders.

Considering, first, squares of an even order: When we set down the numbers 1 to 16 in the form of a square, thus:

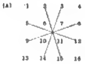
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

we observe that the sum of each diagonal is the same (34), which is to be the sum of the magic square; and, further, that the sum of each pair of cells in a diagonal holding the same relative position in regard to the center is the same, viz., 1 and 16, 6 and 11, 4 and 13, 7 and 10. Now there are eight possible permutations of the cells in each diagonal that preserve this relationship, viz:

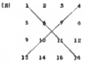
(A)	1	6	11	16	and	4	7	10	13
(B)	16	11	6	1	and	13	10	7	4
(C)	1	11	6	16	and	4	10	7	13
(D)	16	6	11	1	and	13	7	10	4
(E)	6	1	16	11	and	7	4	13	10
(F)	11	16	1	6	and	10	13	4	7
(G)	6	16	1	11	and	7	13	4	10
(H)	11	1	16	6	and	10	4	13	7

By using these eight arrangements of the diagonals as a starting point it is possible to construct eight different designs by which magic squares of the fourth order may be formed. They are as follows:

(A)



(B)



Sum, 34.

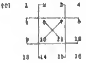
Magic Square

1	15	14	4
12	6	7	9
8	10	11	5
13	3	2	16

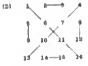
Magic Square

16	2	3	13
5	11	10	8
9	7	6	12
4	14	15	1

(C)



(D)



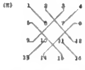
Magic Square

1	14	15	4
8	11	10	5
12	7	6	9
13	2	3	16

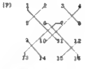
Magic Square

16	3	2	13
9	6	7	12
5	10	11	8
4	15	14	1

(E)



(F)



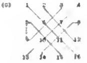
Magic Square

6	12	9	7
15	1	4	14
3	13	16	2
10	8	5	11

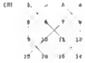
Magic Square

11	5	8	10
2	16	13	3
14	4	1	15
7	9	12	6

(G)



(H)



Magic Square

6	9	12	7
3	16	13	2
15	4	1	14
10	5	8	11

Magic Square

11	8	5	10
14	1	4	15
2	13	16	3
7	12	9	6

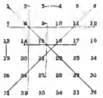
Of course, this by no means exhausts the combinations of 16 cells that form magic squares. Again referring to Fig. 1 we observe that the sum of the first and fourth horizontal rows is 68, which is equal to the sum of the second and third rows. As we rearranged the cells in the diagonals, so we may rearrange the rows of cells, going through the eight permutations that preserve the original relationship, and apply each design to each rearrangement. Likewise, we may turn the original square through a quarter-circle, obtaining the square:

4	8	12	16
3	7	11	15
2	6	10	14
1	5	9	13

to which the various designs may be applied.

In general it is true that the sum of any pair of cells in a diagonal holding the same relative positions in regard to the center is the same, and a factor of the sum of the magic square.

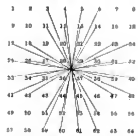
As we pass to squares of higher orders it becomes obvious that the number of permissible permutations of the cells in the diagonals increases rapidly, so that it would seem that there were many possible designs for magic squares of the higher orders. The following designs illustrate several types of designs.



Sixth order. Sum, 111.

Magic Square

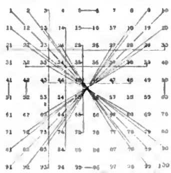
36	32	4	3	5	31
12	29	27	10	26	7
19	17	22	21	14	18
13	20	16	15	23	24
25	11	9	28	8	30
6	2	33	34	35	1



Eighth order. Sum, 260.

Magic Square.

1	2	62	61	60	59	7	8
9	10	54	53	52	51	15	16
48	47	19	20	21	22	42	41
40	39	27	28	29	30	34	33
32	31	35	36	37	38	26	25
24	23	43	44	45	46	18	17
49	50	14	13	12	11	55	56
57	58	6	5	4	3	63	64



Tenth order. Sum, 505.

Magic Square

100	99	93	4	6	5	7	8	92	91
90	12	88	84	16	15	17	83	19	81
30	79	23	77	75	26	74	28	72	21
31	39	68	67	65	36	64	63	32	40
51	52	48	47	56	55	44	43	49	60
41	42	53	54	46	45	57	58	59	50
61	62	38	37	35	66	34	33	69	70
71	29	73	27	25	76	24	78	22	80
20	82	18	14	85	86	87	13	89	11
10	9	3	94	96	95	97	98	2	1

In the sixth order design, 3 and 33 might have been interchanged instead of 2 and 32; then 13 and 18, 2 and 5, 7 and 26, 9 and 10, and 14 and 20 would interchange instead of those given. The changes in the diagonals would remain the same. The resulting magic square would be:

36	5	33	4	2	31
25	29	10	9	26	12
18	20	22	21	17	13
19	14	16	15	23	24
7	11	27	28	8	30
6	32	3	34	35	1

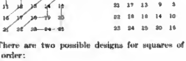
Thus the type designs may sometimes be varied.

It will be found in the foregoing squares that the difference between the sum of any row, horizontal or vertical, and the sum of the magic square is an even number.

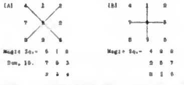
Passing to squares of odd orders: By setting down the nine digits in the form of a square thus:

1	2	3
4	5	6
7	8	9

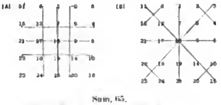
we observe that the sum of each central row of cells is equal to the sum of the diagonal. Further, the difference between the sum of the first horizontal row and the sum of the magic square is an odd number (15 − 6 = 9). It is, therefore, impossible to construct a symmetrical design with the digits in this order. In the case of a square of the fifth order the difference between the sum of the first row and the sum of the magic square is an even number (65 − 15 = 50), but the difference between the sum of the second row and the sum of the magic square is an odd number (65 − 40 = 25). In order to obtain an odd square that fulfills the conditions under which a symmetrical design may be constructed, turn the square so that the diagonals become the centrals and vice versa. Thus,



There are two possible designs for squares of the third order:



In a square of the fifth order there are eight permissible permutations of the cells of the diagonals, as in the case of the fourth order. These serve as the basis of eight designs:



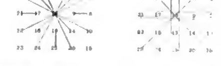
Sum, 65.

Magic Square (A)

11	24	7	20	3
4	12	25	8	16
17	5	13	21	9
10	18	1	14	22
23	6	19	2	15

Magic Square (B)

15	16	7	4	21
6	14	25	18	2
17	5	13	21	9
24	8	1	12	20
3	22	19	10	11

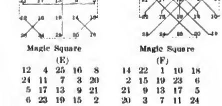


Magic Square (C)

11	20	7	24	3
10	14	1	18	22
17	21	13	5	9
4	8	25	12	16
23	2	19	6	15

Magic Square (D)

15	6	19	2	23
16	12	25	8	4
9	5	13	21	17
22	18	1	14	10
3	24	7	20	11

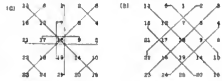


Magic Square (E)

12	4	25	16	8
24	11	7	3	20
5	17	13	9	21
6	23	19	15	2
18	10	1	22	14

Magic Square (F)

14	22	1	10	18
2	15	19	23	6
21	9	13	17	5
20	3	7	11	24
8	16	25	4	12



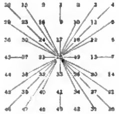
Magic Square (G)

12	16	25	4	8
6	15	19	23	2
5	9	13	17	21
24	3	7	11	20
18	22	1	10	14

Magic Square (H)

14	10	1	22	18
20	11	7	3	24
21	17	13	9	5
2	23	19	15	6
8	4	25	16	12

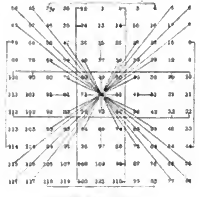
In the following designs, the squares have been first rearranged according to the scheme already given.



Seventh order. Sum, 175.

Magic Square

28	35	8	9	2	47	46
21	23	34	1	40	11	45
36	20	24	33	18	38	6
37	43	19	25	31	7	13
44	12	32	17	26	30	14
5	39	10	49	16	27	29
4	3	48	41	42	15	22

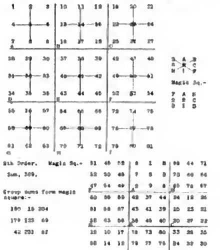


Eleventh order. Sum, 671.

Magic Square

66	77	4	23	120	1	116	3	34	117	116
55	65	46	35	108	13	98	15	16	105	115
114	68	64	75	36	37	26	95	94	18	44
89	79	53	63	74	25	84	83	93	19	9
10	20	80	52	62	73	72	82	30	90	100
111	101	81	91	51	61	71	31	41	21	11
22	32	92	40	50	49	60	70	42	102	112
113	103	29	39	38	97	48	59	69	43	33
78	104	28	27	96	85	86	47	58	54	8
7	17	106	107	24	100	14	87	76	57	67
6	5	88	119	12	121	2	99	118	45	56

Orders whose factors are numbers for which designs are known are easily constructed; e. g., a square of 81 cells may be arranged as nine groups of nine cells each. Each group is treated as a third order square, and the groups are themselves treated as a third order square.



In the same way a magic square of the twelfth order may be made by forming nine groups of 25 cells each or 25 groups of nine cells each, and so on. The numbers may be written consecutively, instead of in groups as in the diagram, and then divided off into groups. Also the various types of designs for an order may be used indiscriminately.

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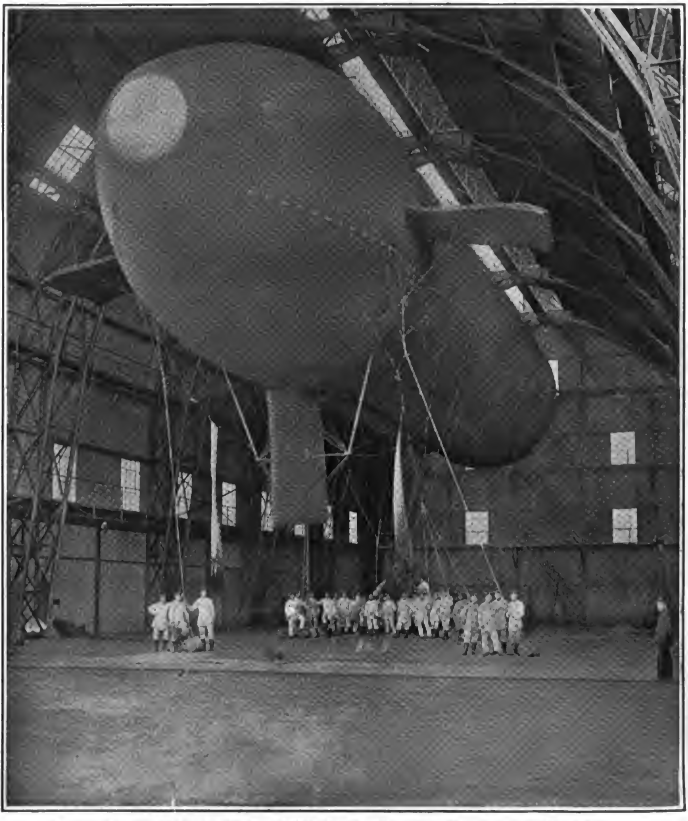

End view of Parseval airship in its shed, showing the stabilizing fins at the sides of the envelope and the vertical rudder beneath.

THE MILITARY PARSEVAL AIRSHIP USED BY THE GERMAN ARMY.—[See page 228.]

The Germplasm as a Stereochemic System—I[*]

Every Individual is a Chemical Entity That Differs in Characteristic Particulars from Every Other

By Edward Tyson Reichert, University of Pennsylvania

The[*] discovery, in 1883, by Dr. S. Weir Mitchell and myself that the toxic principles of the venoms of serpents are albuminous marked an era in the chemistry, physiology and pathology of proteins, and among other things laid the foundation of our knowledge of bacterial and other toxalbumins. Since that time our information of the properties of albuminous substances, then extremely meager and somewhat chaotic, has greatly advanced, and many investigations have been made to determine the precise nature of these poisons, with the effect of more or less modifying the statements we then set forth. The astonishing fact that these terribly lethal substances were found by the tests of the day to be proteins, and that apart from their toxic properties they were indistinguishable from corresponding bodies that are ingested as food or derived therefrom by the processes of digestion, or found as normal constituents of the living tissues generally, naturally led me to much speculation and ultimately to the pursuit of the very elaborate series of researches that I have been carrying on during the past decade under the auspices of the Carnegie Institution of Washington, reports of two of which have appeared as Publications Nos. 116 and 173.

It would be futile for me to attempt, within the necessarily restricted time that can reasonably be allotted to the reading of a communication, to present in a satisfactory form even the briefest summary of the very voluminous results and conclusions that are embodied in these works, or even an outline of their bearings, upon a vast number of problems of normal and abnormal biology, so that perforce my remarks shall be limited to a fragment—a fragment which bears upon one of the most baffling yet all-absorbing problems of life, why "like begets like."

A. THE SPECIFICITY OF STEREOISOMERIDES IN RELATION TO GENERA, SPECIES, ETC.

These researches have as their essential basis the conception that *in different organisms corresponding complex organic substances that constitute the supreme structural components of protoplasm and the major synthetic products of protoplasmic activity are not in any case absolutely identical in chemical constitution, and that each such substance may exist in countless modifications, each modification being characteristic of the form of protoplasm, the organ, the individual, the sex, the species and the genus.* This conception was supported not only by the extraordinary differences noted between the albuminous substances of venom and those of other parts of the serpent, but also by the results of the investigations of Hanriot who described marked differences in the properties of the lipases of the pancreatic juice and the blood; of Hoppe-Seyler and others who stated that the pepsins of cold- and warm-blooded animals are not identical; of Wróblewsky and others who recorded differences in the pepsins of mammals; of Kossel and his students who found that the protamins obtained from the spermatozoa of different species of fish are not identical; and of various observers who have noted that the erythrocytes of one species when injected into the blood of another are in the nature of foreign bodies and rapidly destroyed. During subsequent years, and especially very recently, data have been rapidly accumulating along many and diverse lines of investigation which collectively indicate that every individual is a chemical entity that differs in characteristic particulars from every other. To anyone familiar with the advances of biochemistry and with the trend of scientific progress toward the explanation of vital phenomena on a physico-chemical basis, it will be obvious that if the conception of the non-uniform constitution of corresponding proteins and other corresponding complex organic substances in different organisms and parts of organisms were found to be justified by the results of laboratory investigation a bewildering field of speculation, reasoning and investigation would be laid open—a field so extensive as to include every domain of biological science, and seemingly to render possible, and even probable, a logical explanation of the mechanisms underlying the differentiation of individuals, sex, varieties, species and genera; of the causes of fluctuations and mutations; of the phenomena of Mendelism and heredity in general; of the processes of fecundation and sex-determination; of the tolerance of certain organisms to organic poisons that may be extremely virulent to other forms of life; of tumor formation, reversions, malformations and monsters; of anaphylaxis, certain toxemias, immunities, etc.; and of a vast number of other phenomena of normal and abnormal life which as yet are partially or wholly clothed in mystery.

Some years previous to the discovery of the nature of the lethal constituents of venoms, Pasteur found that there exist three kinds of tartaric acid which, because of different effects on the ray of polarized light, are distinguished as the dextro-, levo- and racemic-tartaric acids, the dextro form rotating the ray to the right, the levo form to the left, and the racemic form not at all. When these acids were subjected in separate solutions to the actions of *Penicillium glaucum* fermentation proceeded in the dextro form, but not in the levo form, while in the solution of the racemic acid, which is a mixture of the dextro and levo acids, the dextro form disappeared, leaving the levo moiety unaffected. All three acids have the same chemical composition and chemical properties but differ strikingly in their effects on polarized light and in nutritive properties. Identical or corresponding peculiarities have since been recorded in relation to a large number of substances. Thus, of the twelve known forms of hexoses, or glucoses, only the dextro forms are fermentable, that is, capable of being used by certain low organisms as food, but not all are thus available, and, moreover, those which are show marked differences in the degree of fermentability. In the case of other substances *Penicillium* may consume the levo form but not the dextro form. Other organisms show similar selectivities, using either dextro or levo form, or both, but in the latter case in unequal degree. Even more striking instances have been recorded in the actions of poisons, as for instance, dextro-nicotine is only half as toxic as the levo form; dextro-adrenalin has only one twelfth the power of the levo form; racemic-cocaine has a quicker and more intense but less lasting action than the levo form; the asparagines, hyoscines, hyoscyamines and other substances have been found to exhibit marked differences in accordance with variations in their optical properties. With other bodies belonging to this category it may be found that one form is sweet while another is tasteless; another may be odorous but its enantiomorphous form without odor.

To the foregoing there may be added examples of other substances that exist in several forms but which physico-chemically belong to a different class. Thus, nitroglycerine may exist in forms that are so different that under given conditions of temperature and percussion one is explosive and the other non-explosive. Differences in substances which are found in allotropic forms may be as marked as in any of the preceding illustrations, as for instance, in the case of phosphorus, which is familiar as the yellow, white, black and red varieties, all of which with the exception of red phosphorus are exceedingly poisonous while the latter is inert. The ortho, meta and para forms of a given substance may exhibit more or less marked physiological and toxicological variations, and so on.

The explanation of the remarkable differences shown by these substances, which differences are paralleled by those manifested by the lethal and innocuous proteins of the serpent, the pepsins, the protamins and the red blood corpuscles, is to be found in the results of two independent but intimately related lines of physico-chemical research: (1) The investigations of Van't Hoff and LeBel and subsequent observers which have laid the foundation of a new, and to the biologist and physician, an extraordinarily important development of chemistry known as stereochemistry—a department that treats of the arrangements of the atoms, groups and masses of molecules, or in other words of intramolecular arrangement or configuration of molecular components in the three dimensions of space. (2) The investigations of Willard Gibbs and others which have given us the "phase rule" which defines the phases or forms in which a given substance or combination of substances may exist owing to differences in intramolecular and extramolecular arrangements and concentration of their components in relation to temperature and pressure.

According to stereochemistry a given substance may exist in multiple forms dependent upon differences in the configuration of the molecule, all of which forms have in common the fundamental chemical characteristics of a given prototype, yet each may have certain properties which positively distinguish it from the others. Theoretically, such substances as serum albumin, serum globulin, hemoglobin, starch, glycogen and chlorophyl may be produced by nature in countless modified forms owing to differences in intramolecular arrangements. Miescher has estimated that the serum globulin molecule may exist in a thousand million forms. Substances that exist in such multiple forms of a prototype are distinguished as stereoisomers. The remarkable fact has been noted by Fischer and others that stereoisomers may exhibit as great or even greater differences in their properties than those manifested by even closely related isomers, which latter in comparison with stereoisomers are distantly if at all chemically related. As already instanced, so slight a change in molecular configuration as gives rise to dextro and levo forms may be sufficient to cause definite and characteristic and even profound differences in physical, nutritive and physiological properties.

In accordance with the "phase rule" a substance or a combination of substances may exist in the form of heterogeneous or homogeneous systems, a heterogeneous system consisting of a number of homogeneous systems, each of which latter is a manifestation of an individual phase and distinguishable from the others by physical, mechanical, chemical or physiological properties. The number of phases of a heterogeneous system increases with the number of component systems, and the number of the latter is in direct relationship to the number of independent variable constituents. Therefore, by means of variations of either or both intramolecular or extramolecular arrangement the number of forms of a substance or combination of substances may range from few to infinite.

Our means of differentiating stereoisomers are, on the whole, limited and for the most part crude, and while it has been found that differences so marked as those referred to may be detected by the ordinary procedures it seems obvious that the inherent limitations of such methods render them inadequate where a large number of stereoisomerides or related bodies which may exhibit only obscure modifications are to be definitely differentiated, so that other and more sensitive methods must be sought, or at least special methods that are adapted to exceptional conditions. The results of much preliminary investigation in this direction led in one research to the adoption of the crystallographic method, especially the use of the polarizing microscope, which in its very modern developments of analysis has demonstrated that substances which have different molecular structures exhibit corresponding differences in crystalline form and polariscopic properties; and, moreover, that the "optical reactions" may be found to be as distinctive and as exact analytically as the reactions obtained by the conventional methods of the chemist. Furthermore, the necessities of the hypothesis demanded the selection of a substance for study of a character which upon theoretical grounds might be expected to exist in nature widely distributed and readily procurable, and, as a consequence, hemoglobin was selected.

In the investigation of the hemoglobins I had as a co-worker Prof. Amos Peaslee Brown. Hemoglobins were examined that were obtained from over 100 animals, representing a large variety of species, genera and families. From the data recorded certain facts are especially conspicuous, among which may be mentioned the following:

1. The constant recurrence of certain angles, plane and dihedral, in the hemoglobins of various species, even when the species are widely separated and the crystals belong to various crystal systems. This feature indicates a common structure of the hemoglobin molecules whatever their source.

2. The constant recurrence of certain types of twinning in the hemoglobins, and the prevalence of mimosie. This has the same significance as the foregoing.

3. The constancy of generic characters in the crystals. The crystals of the various species of any genus belong to a crystallographic group. When their characters are tabulated they at once recall crystallographic groups of inorganic compounds. The crystals of the genus *Felis* constitute an isomorphous group which is as strictly isomorphous as the groups of rhombohedral and orthorhombic carbonates among minerals, or the more complex molecules of the members of the group of monosymmetric double sulphates.

4. The crystallographic specificity in relation to species. The crystals of each species of a genus, when they are favorably developed for examination in the polarizing microscope, can usually be distinguished from each other by definite angles and other properties, while preserving the isomorphous character belonging to the genus. Where on account of difficulty of measurement the differences cannot be given a quantitative value variations in habit and mode of growth of the crystals often show specific differences.

5. The occurrence of several types of oxyhemoglobin in members of certain genera. In some species the oxyhemoglobin is dimorphous and in other trimorphous.

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[*] Read by title at the meeting of the American Philosophical Society, April 25th, 1914, and in full before the Society of Normal and Pathological Physiology of the University of Pennsylvania, April 28th, 1914.

Where several types of crystals occur in this way in the species of a genus the crystals of each type may be arranged in an isomorphous series. In other words, certain genera as regards the hemoglobins are isodimorphous and others isotrimorphous.

6. When orders, families, genera or species are well-separated the hemoglobins are correspondingly markedly differentiated. For instance, so different are the hemoglobins of *Aves*, *Marsupialia*, *Ungulata* and *Rodentia* that there would be no more likelihood of confounding the hemoglobins than there would be of mistaking the animals themselves. Even where there is much less zoological separation, as in the case of the genera of a given family, but where there is well-marked zoological distinction, the hemoglobins are so different as to permit readily of positive diagnosis. When, however, the relationships are close the hemoglobins are correspondingly close, so that in instances of an alliance such as in *Canis*, *Vulpes* and *Urocyon*, which genera years ago were included in one genus (and doubtless correctly) the hemoglobins are very much alike, and in these cases they may exhibit closer resemblances than may be found in general in specimens obtained from well-separated species of a genus.

So distinctive zoologically are these modified forms of hemoglobins that we had no difficulty in recognizing that the common white rat is the albino of *Mus norvegicus* (*Mus norvegicus albus* Hatal) and not of *Mus rattus* as almost universally stated, and that Ursidæ are related to Phocidæ (as suggested by Mivart 30 years ago) but not to Canidæ as stated in modern works on zoology. Moreover, we were quick to detect errors in labeling, as for instance, when a specimen marked as coming from a species of *Papio* was found to belong to one of the Felidæ. Generic forms of hemoglobin when obtained from well-separated genera are, in fact, so different in their molecular structures that when any two are together in solution they do not fuse to form a single kind of hemoglobin or a homogeneous solution, but continue as discrete disunited particles, so that when crystallization occurs each crystallizes independently of the other and without modification other than that which is dependent upon such incidental conditions as are to be taken into account ordinarily during crystallization. Thus, the hemoglobin of the dog crystallizes in rhombic prisms which have a diamond-shaped cross-section; that of the guinea-pig in tetrahedra; that of the squirrel in hexagonal plates; and that of the rat in elongated six-sided plates. When any two of these hemoglobins are together in solution and crystallization occurs, each appears in its own form. Such phenomena indicate that the structures of the hemoglobin molecules are quite different; in fact, more differentiated than the molecules of members of an isomorphous group of simple carbonates, such as the carbonates of calcium and magnesium which when in separate solutions crystallize in rhombohedrons whose corresponding angles differ 2 deg. 15 min., but which when in molecular union, as in the mineral dolomite, crystallize as a single substance which has an intermediate angle.

Upon the basis of our data it is not going too far to assume that it has been satisfactorily demonstrated theoretically, inferentially and experimentally that at least this one substance (hemoglobin) may exist in an inconceivable number of stereisomeric forms,[2] each form being peculiar to at least genus and species and so decidedly differentiated as to render the "hemoglobin crystal test" more sensitive in the recognition of animals and animal relationships than the "zooprecipitin test."

Subsequent to the research referred to, investigations have been pursued in the study of hemoglobins from various additional sources, especially from representatives of *Primates*, with the result in the latter case of finding indubitable evidence of an ancestral alliance of man and the man-like apes.

More or less elaborate studies by crystallographic and other methods have also been made with other albuminous substances and with starches, glycogens, phytocholesterins, chlorophyls and other complex synthetic products of animal and plant life, especially with starches, of which over 300 specimens were examined that were obtained from different plant sources, including representatives of a considerable number of families, genera, species, varieties and hybrids. In all of these investigations the results are not only in full accord with those of the hemoglobin researches but also in some instances of broader significance because by better methods of differentiation in some cases it was found possible to recognize not only peculiarities as regards genus or species but also varieties and hybrids, and even to trace in hybrids with marked definiteness the transmission of parental characteristics.

Summing up the results of these independent but interwoven researches we find that the modified forms of each of these substances lend themselves to a very definite system of classification, and to one that is in general accord with that of the botanist and zoologist, that is, each genus is characterized by a distinctive type of hemoglobin, albumin, starch, etc., as the case may be, which may be designated the generic-type; every species of the genus will have a modification of this type, which is a species-type, or generic primary sub-type; and every variety of a species will have a modification of the species-type, that is a variety-type, or generic secondary sub-type, or species sub-type. In fact, it seems clear that with revisions of present classifications that are certain to come there will be found definite family types; and, moreover, that with improved methods of differentiation there will be discovered positively distinctive sex- and individual-types. This last statement already has support in the results of collateral lines of research which bear upon the specificities of enzymes, anaphylaxis, precipitin reactions, immune sera, etc.

From the foregoing data it seems obvious that *the complex organic substances which may be assumed to constitute the essential fundamental constituents of protoplasm and the immediate complex synthetic products of protoplasmic activity may exist in exceedingly numerous or even countless stereoisomeric forms, each form being peculiarly and specifically modified in relation to genus, species, variety, race, sex, individual or even part of an individual.*

II. PROTOPLASM A COMPLEX STEREOISOMERIC SYSTEM.

The next logical step in our investigation is manifestly the study of the bearings of these stereoisomers, as such and in their variable combinations and associations, upon the structure, processes and products of protoplasm. Protoplasm according to the modern developments of biochemistry is to be regarded as being in the nature of an extremely complex, labile aggregate of proteins, fats, carbohydrates and other substances that are peculiarly associated to constitute a physico-chemical mechanism. The possible number of "phases" in which such a system can exist varies with the forms of the stereoisomerides and in general with the number and independent variability of the components. In such a mechanism we conceive that the number of variables is inconceivably great. From analogy we believe that such mechanisms are so extremely sensitive that the properties and processes may be modified by even so slight a change as the substitution of one form of stereoisomeride for another of the same prototype. Were it practicable to examine all of the most complex of the organic structural components of protoplasm it doubtless would be found that every one exists in a form that is peculiar to the individual and his position in classification. Moreover, we must conceive that the components of protoplasm are as specific in relation to the *form* of protoplasm as are the peculiar forms of stereoisomers, so that different forms of protoplasm are characterized physico-chemically (1) by the peculiarities of the stereoisomerides, and (2) by the peculiarities of the kinds, combinations, associations and arrangements of the components in the three dimensions of space.

In accordance with the foregoing, the human organism may be regarded as being a highly organized composite of heterogeneous physico-chemical systems that are composed of a vast number of parts, each such part representing a particular "phase" of the system and being physically, mechanically, chemically and functionally an individual interacting unit of the aggregate. Hence, it follows that the sum or totality of these peculiarly modified stereoisomers *per se*, and of their arrangements with the associated components constitutes a "stereochemic system" that is peculiar to the cell; that the sum of the cell-systems is peculiar to the tissue; that the sum of the tissue-systems is peculiar to the organ; and that the sum of the organ-systems is peculiar to the individual.

While the living organism had been for years recognized as being in the nature of an exceedingly complex physico-chemical aggregate of interacting independent and interdependent parts that constitute a single working unit, it has been in only recent years that the mechanisms that bring about co-operative activities of the various parts has been made clear. The governing influences of the nervous system were found inadequate even in the highest organisms, not to speak of forms of life in which such actions occur but in which there is apparently a total absence of nervous matter. As an associate of the nervous system, and doubtless far antedating it in organic evolution, is a correlative mechanism of a chemical character that is of the greatest importance, and doubtless equally so throughout the whole range of living organisms from the lowest to the highest. Every living cell whether it be in the form of a unicellular organism or a component of a multicellular organism is undoubtedly in the nature of a heterogeneous stereochemic system, each of the component parts of the system forming substances which may affect directly or indirectly the activities of the processes of the other parts; likewise every cell of a multicellular organism is not only in itself a heterogeneous system but a part of a number of associated heterogeneous systems and which by virtue of certain of its products, with or without the agency of the blood-vascular or lymph-vascular systems, may exercise influences upon other structures, which structures may have or seemingly not have either structural or physiological relationship. Thus we find that a secretion formed in the pyloric glands of the gastric mucosa may excite the glands of the cardia; that growth is determined by some product or products of the pituitary body that are carried to the various structures; that the liver, pancreas and intestinal glands are excited to secretory activity by a peculiar substance formed in the duodenal and jejunal mucosæ; that carbohydrate metabolism in the liver and muscle is influenced to a profound degree by hormones that are formed in the pancreas; that lactation is determined essentially by substances derived from the corpus luteum, placenta and involuting womb; that the periods of ovulation and menstruation are inhibited by secretions of the corpus luteum; that vitally important states of activity of the generative organs are directly associated with functions of the adrenal glands; and that normal development, especially of secondary sexual characters, is intimately related to the ovaries and testicles. To these extraordinary correlations might be added many others. Some of the bodily structures are in this way so definitely associated in their activities as to constitute co-operating or interacting systems, so that the tissue products are complementary, supplementary, synergistic or antagonistic in their influences upon given structures. Such correlations must be, for perfectly obvious reasons, one of the most primitive forms of interprotoplasmic correlation, and we are justified, upon the basis of our present knowledge, in the conclusion that each active part of a cell, each cell, each tissue and each organ contributes products which may affect the activities of functionally related or unrelated parts. Hence would follow the dictum that *not only is every part of a cell, every cell, every tissue and every organ an individualized stereochemic unit but also that its operations, and hence the nature of its products, must be subject directly or indirectly to the influence of every other active part of the organism, however different the structures and functions may be.*

(*To be concluded.*)

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[2] Even if we assume that the different forms are not, strictly speaking, stereoisomers it must be admitted that hemoglobin exists in forms that are specifically modified in relation to genera and species.

Elevators for Eels

A NEW method of eel-culture practised by a Dane named Nielsen is described in the annual government report on the fresh water fisheries of England and Wales. Nielsen is the proprietor of a piece of low-lying land on the Ise Fjord in the Island of Zeeland, so banked in as to form a pond of about 432 acres, which is on an average about 2 feet deep. The water in the pond is somewhat brackish, and this permits of the development of abundant quantities of Mysidæ, and upon these the eels feed and thrive. The proprietor has contrived, however, that either salt water from the Fjord or fresh water from the adjacent canal can be pumped into the lake as desired. The eel spends the greater part of its life in fresh water; but on attaining sexual maturity it instinctively seeks the sea, where it spawns (this statement appears to apply to all the eels of Western Europe) far out in the Atlantic in the neighborhood of the Sargasso Sea. The young eels, in their helpless larval stage, drift with the ocean currents until they become elvers, when they make their way into fresh waters, where they remain till they have reached the stage of maturity, at which nature urges them to return to the sea which gave them birth.

Nielsen observed that the elvers annually appeared in the Ise Fjord alongside his lagoon in the early spring months, and he conceived the ingenious idea of attracting them into a trap by means of a supply of fresh water, which is allowed to run through a sluice constructed in the bank of the lagoon, and thence down a sloping platform into the Fjord. He found that when he wished to discharge a volume of water through the sluice sufficient to have such an effect upon the surrounding salt water as to attract the elvers to its neighborhood, the flow was too strong to allow the elvers to ascend the slope without assistance. He therefore constructed bands of twisted straw, which are attached to the sloping platform, and allowed to drift out into the Fjord. The elvers are able to wriggle along these bands, and by means of them to make their way up the slope into a specially constructed trap, from which they are easily taken, and being counted, are transferred to the lagoon. By means of the trap, some 50,000 elvers were introduced in 1905, and in subsequent years the number has varied from about 60,000 in 1906 to about 300,000 in 1913.

When, on the other hand, Nielsen requires ripe, fully-grown eels for the market, he again takes advantage of the natural instinct of the mature eel to migrate toward salt water. Salt water from the Fjord is pumped over the dam into the pond through boxes specially constructed for catching the eels, which, being attracted by the salt water, enter the boxes, and are there trapped. By this means as many as 300 pounds of eels have been caught in a single night, and the proprietor can take eels when he pleases. In 1913 it was estimated that the weight of eels taken was about 13,000 pounds.—*The English Mechanic.*

The Parseval Airship Used by the German Army

A Type of Non-Rigid Dirigible That has Proved a Success Abroad

By Carl Dienstbach

When the "air balloon" was invented by the Montgolfiers and Charles, the belief was general that the most difficult part of the problem of human flight was then solved, and that it would require but slight additions to the inflated bag to make it a useful means of transportation. Hundreds of schemes and attempts were suggested to supply the "slight additions." How astonished one of these early half "improvers" would be if he could see his dream come true!

Perhaps the most practical airship of our day is the Parseval, which in truth may be called a gas bag with slight additions. The Parseval airship owes its great advantages precisely to the fact that the inventor did not aim at creating something essentially different from a balloon, that he intended to preserve every single good and practical feature of the time-honored "spherical," and that he strove for his comparatively modest goal with so much ingenuity.

A sight not altogether unfamiliar, would greet the eye of Parseval's eighteenth century admirer. First, he would be pleased to learn that the aircraft of his own day, after remaining exactly the same for over a century, had suddenly seen great technical improvement at the beginning of the twentieth century. The gas-retaining qualities, the strength and toughness, the lightness of the new double rubberized and biased balloon cloth would be a revelation to him. Without that fabric the new airship would never have come into existence. But what should otherwise appear really novel to him might only seem as if it were like a "touch" added here and there, but the "touch" of a master hand—comparable to the slight application of the brush, by which great painters are known to have turned a pupil's work into an everlasting masterpiece. Thus the fundamental change from the spherical balloon—the elongated gas bag—means in the Parseval an almost true "form of minimum resistance." This fact is due to the very propitious circumstances which favored the work of Major von Parseval.

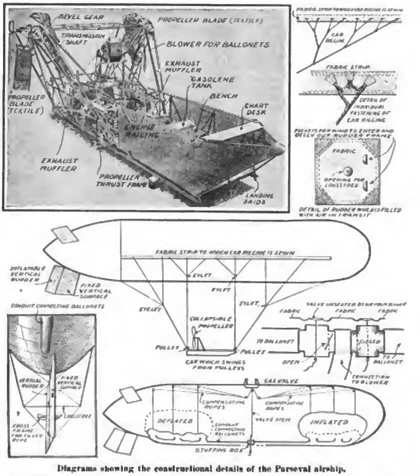
It happened that the great German "Society for the Study of Motor Aeronautics" was founded at the initiative of the emperor at the exact date that his first experimental airship was tested. This organization counted among its members the most prominent financiers and the ablest scientists and engineers of the fatherland. Major von Parseval's work presently became the point around which its endeavors crystallized.

All its energies were soon concentrated on the improvement of his simple system, which was justly recognized to promise immediate success. After the model of Prof. Zahm's aero-dynamical laboratory in Washington, the society built a laboratory for aero-dynamical research at Goettingen, and put Prof. Prandl of the Goettingen University in charge. In a big Zahm wind tunnel the best shape for the hull was developed on tin models, thus verifying the prediction of Prof. Woodward, president of the St. Louis International Aeronautical Conference, 1904, that the result of Prof. Zahm's and Prof. Nipher's work combined (the latter on the distribution of wind pressure on structures), both submitted to that conference, would result in a form of least resistance for the hull of an airship. Prof. Prandl investigated the pressure by means of small holes bored along the whole surface of his models and communicating with many interior compartments, which were alternately connected to pressure gages. He was thus enabled to draw accurate curves. The almost spherical front of the shape evolved by Prof. Prandl would seem most familiar to the man of the eighteenth century. The big fish-like steadying fins at its stern, so conspicuous by their simplicity, would be a surprise. These are, indeed, the principal contributions of the twentieth century to the old balloon. Invented by the late Col. Renard as early as 1884, they remained a secret up to 1902. The reason for the specially efficient use to which they were put by Major von Parseval is the fact that he, in a way, had independently reinvented them. Even the rudder is so deftly hinged to these fins that it hardly shows. Yet it has an unusually efficient shape and position.

The resemblance of the Parseval to an ordinary spherical is due to the fact that it was evolved from a balloon. Parseval first developed an elongated captive balloon that could be operated in heavy winds. In co-operation with the late Capt. von Siegsfeld, he did this so well that his so-called "Drachen Ballon" is to-day introduced into the military service of most powers. To his airship it is almost as closely related as a glider is to an aeroplane, or a towing barge to a steamer. It offered two formidable problems, steadying it in the wind, and properly suspending the car. To arrive at the nucleus of the Parseval airship nothing more was needed than to modify the "Drachen Ballon." The rounded, sausage-shaped steadying bag of the "Drachen Ballon," whose excessive drag prohibited its use as an airship, was first turned into three rectangular hollow "mattresses" stiffened by internal pressure and part of the balloon. The "Drachen Ballon's" ingenious suspension, flexible to prevent excessive rocking in the gusts, was easily turned into the famous Parseval airship suspension, which allows a "car on wheels" to roll ahead or back on steel ropes, with the air pressure against the gas bag.

To these ingenious devices the Parseval airship owes its existence. Without them it would not be feasible to suspend the car low enough to distribute its weight sufficiently over the whole length of the bag to make it possible to dispense with any sort of a stiffening frame. The ship would pitch so violently that it could not be propelled. Still this very feature is a weak point of the "non-rigid" system. Its inventor personally remarked to the writer, when complimented on the truly beautiful appearance of the "rigging": "Its air resistance is something to be reckoned with." The great saving of weight it permits is thus partly offset. A Parseval has also most of the faults as well as the virtues of an ordinary balloon, while the purely rigid construction, as represented by Zeppelin, Schuette, and others, aims at turning the aerostat into a true "ship." Their goal is infinitely higher, and therefore fundamentally entitled to a more lenient criticism. The ample carrying power of a non-rigid airship makes indeed a large Parseval (type B) a thing of amazing solidity. For instance, the thinnest rope in the suspension has the thickness of a man's finger. The steel wire cables on which the car rolls have the same thickness. The car, detached, as to size and strength, looks almost exactly like a "freak" gasoline launch.

Its board floor, solid as a boat's deck, is 30 feet long and over 6 feet wide. The frame carrying the propellers is made of steel tubes as thick as a man's arm. The center of each propeller is about 12 feet above the floor of the car, and each is also slightly over 10 feet in diameter. The width of each of the four rectangular blades is slightly less than 2 feet. The non-rigid propellers, very inconspicuous when at rest, and directly attached to the car, also increase the resemblance of the Parseval to an ordinary balloon. Each propeller has a girder work hub of steel, skillfully designed to withstand all working stresses with a minimum of material, to which hub four cloth blades are fastened like so



Diagrams showing the constructional details of the Parseval airship.

The Zeppelin. The Parseval. The Gross.

Three typical German airships.

many flags. The blades are made of two strong wire ropes with cross pieces of steel, sewn into a double layer of heavy balloon fabric. Major von Parseval explained to the writer that by correctly proportioning the weight of different parts of the flexible blade to a given speed of revolution and a given pitch, any desired form of the blade could be obtained from centrifugal force acting against the pressure of propulsion. It has indeed been claimed that these blades are more efficient than solid ones. In the newest Parseval ships they are made semi-rigid—just stiff enough to preserve their shape when at rest—as a matter of convenience.

The Parseval power plant has been brought to such a state of reliability that it should furnish a fitting model for any kind of aircraft, especially flying machines. There are, of course, two motors. To insure the highest possible economy when only one motor is running there is a coupling arrangement by which two propellers in tandem may be driven by either motor alone. The girder construction of the hubs has been fashioned into a mechanism that permits altering and even reversing the pitch of the propellers while they are running. This is done by a convenient hand wheel at the side of the car. The pitch is always adjusted to the most economical number of the motor's revolutions. With one motor driving both propellers the pitch is lowered until the propellers run quite as fast as with two motors.

The last reason for the striking resemblance of the Parseval airship to an ordinary balloon is the absence of any horizontal rudders. Steering up and down, i. e., tilting the keel, is effected by a principle similar to that which makes an ordinary balloon go down. Gas is removed from the end to be lowered. It is not lost, but merely transferred to the opposite end, whose lift is thus increased at the same rate that the buoyancy of the other end is diminished. This is done by means of two air ballonets (each with one eighth of the cubic capacity of the gas space) in the opposite ends of the envelope, a powerful blower, driven by a double belt from each motor, and large distributing valves for the air blast. All this forms a specially substantial and conspicuous part of the machinery, and has been designed to stand rough usage. The blower is carried in the propeller frame, some 8 feet above the floor of the car. The vertical air hose leading to the bag is stiffened by strong wooden rings. The large distributing valves of aluminium are at the same time automatic safety valves. They are so attached to the envelope that any excessive gas pressure moves a plunger and allows the air to escape. The gas pressure is relieved in this manner as long as either ballonet contains any air. If both are completely emptied they automatically pull the maneuvering gas valve on top of the envelope open, an arrangement copied from the "Drachen Ballon." There is considerable mechanism inside the gas bag which has never been described. This was sketched for the writer by Major von Parseval himself. In order to keep a certain amount of control over the "convulsions" of the ballonets inside while they swell or collapse, a series of cords is fastened to their upper surface. They are united into one rope that runs over a pulley suspended above either ballonet from the inner "ceiling" of the gas bag. Thus the ballonets are made to swell and collapse more evenly. If excessive expansion of the gas by heat or height should ever squeeze all air out of the ballonets this rope, under tension, would exert a pull strong enough to open the gas valve on top. A single gas valve is thus made to serve as both a maneuvering and a safety valve. The valve stem is led through a stuffing box in the bottom of the bag. Two ripping panels and cords, one at either end, are provided, as in a spherical balloon. For the guidance of the pilot there are four pressure gages, one for each air ballonet and one for each end of the gas space. They register in centimeters of water, and consist of U tubes of glass filled with red liquid. The front end of the car is covered by a chart desk. A compass, designed by Prof. Marcuse, is suspended over the pilot's head, who reads the inverted dial from below. A small vertical steering wheel shaped like that of a ship is directly in front of the chart desk. The pressure gages mentioned are attached to the right "gunwale" of the car, and the lines controlling the distributing valves pass down from above also on starboard. The compass may easily be taken down and with an iron tripod attached to "ship shape" brass fittings sunk into the car's board floor. This is done for nautical measurements of the sun's position. There is, of course, in addition to the usual barograph, barometer, statoscope of the spherical balloon, also an air bubble to indicate the "tilt." The frame of the car is made of steel tubes and T girders, covered with wire netting and heavy canvas. A large cylindrical gasoline tank in a cloth casing serves as a back to an elegant bench upholstered in red leather, running across the car, and dividing it into a "bridge" and "engine room." This bench accommodates six passengers. For the pilot and his aides there are camp chairs. The spacious engine room, with the smart iron railing around the motors, differs in no sense from that of a boat, even as to its minute cleanliness. The motors are of the six-cylinder type, each good for 120 horse-power maximum. They were selected after a competition and have never given trouble. The radiators, arranged like an inverted V, close the car in the rear. They are of aluminium, very imposing, each about five feet square, but quite light. Cooling is effected by powerful blowers set in a casting. These spread the blast evenly over the whole radiating surface. The motors are cranked with the throttle almost closed and the propellers are thrown in by clutches.

The rigging is as elaborate and picturesque as that of a clipper ship. It was found that anything could be attached directly to the gas bag, to reinforcing "patches," which doubled and trebled the thickness of the cloth. There is an "equatorial belt" carrying the suspension, and there are many other "patches," some of them shaped like a star, to hold a single rod. The stabilizing fins are now made of steel frames covered with cloth on both sides. The "air mattress" idea has been dropped, but the cloth is still kept from fluttering by allowing the wind to catch in a "mouth" and blow between the two layers. The tiller rope ends in a steel band that fits around a large semi-circular pulley fastened to the rudder. This insures precise action. The stabilizing planes are held in place by a very simple and strong arrangement of rods and stays fastened to the envelope as described above. The suspension branches back with innumerable "crows' feet" (the original ones made of three loops of rope each, sewn to the equatorial belt) from many short hemp ropes into fewer and fewer wire ropes. Everything is flexible. All loops are lined with fittings of aluminium or steel, allowing the ropes to slide with little friction and preventing excessive wear and tear. The car, with four grooved wheels, rolls on two strong inclined cables of twisted steel wires, into which most of the branch ropes finally consolidate. At the same time it swings like a pendulum with parallel motion from six vertical ropes.

A Parseval's handling is nearly as simple as that of the ordinary round balloon. It has been inflated in the open, and it can be landed, by valve and ripping cords, with safety, with disabled motors in a storm. There are many "handling ropes," each with a series of loops, giving a firmer grip. They hang down from the whole length of the bag, and are an integral part of the rigging.

At Frankfort in 1909, during the International Aeronautic Exposition, where the ship ascended, one of these dragging ropes coiled around a man's legs and raised him into the air like a feather, although the balloon had no surplus lift. Thus the lifting power of the propellers and the tilted hull was forcibly shown. The ship was always actually heavier than the air when it left the ground in a slanting direction. Coming down was harder than going up. The consumption of fuel lightens the ship, and it is considered "unsportsmanlike" to let out gas. The low center of gravity, in spite of the flexible suspension, prevents a tilt as sharp as that of the "Zeppelin III," which swoops down like a hawk. The "Parseval III" must "screw itself down" in many spirals. On one occasion, in bright sunshine, it could not come down at all, much to everybody's amusement.

At Frankfort, where the Parseval system was permanently represented by its largest and most serviceable type (6,600 cubic meters, or 223,079 cubic feet, displacement) comparison with the "Zeppelin II" and "Zeppelin III" by visitors at the exposition could easily be made.

The virtues of the Parseval system are so obvious and simple that they can be easily understood from theory. With the Zeppelin system it has been mostly results that counted with the public. Like the Wright flyer among aeroplanes, the Zeppelin among airships has gone farthest and fastest with the lowest power and the least consumption of gasoline and oil. It has lived through the change from night to day and day to night and morning again in a single trip without stopping. It is well known how much less gas these changes in temperature and height would have meant for an airship made like an ordinary balloon. Still, compared to the Parseval, which may be said to have practically reached the pinnacle of its development, the Zeppelins may not have half realized as yet the inherent advantages of a rigid construction. They had to pay the full toll for their "extravagant" mode of handling, but did not nearly enjoy the full recompense. The Parseval is the airship of to-day, the Zeppelin that of the future.

The fundamental difference between the two systems may be stated thus: The Parseval, with its sharp distinction between "car" and "balloon," always remains a "unit," more or less. A Zeppelin, in larger sizes, becomes purely a conglomeration. A Zeppelin's weight, therefore increases at a lower rate than its lift. The "Deutschland" points the way to the giants of the future, with no cars, but a continuous "hold" and the load everywhere directly under the gas that lifts it. A Zeppelin may also have an "upper deck." It is there already; for on the uppermost "strake" a man may now safely walk from end to end after having ascended through the hull. A few thin boards and a light aluminium railing will complete it.

The Parseval ships at present are built in the dimensions given in the table.

Displacement, Cubic Meters.	Length, Meters.	Maximum Diameter, Meters.	Maximum Width Over Fins, Meters.	Maximum Height, Meters.	Car Length, Meters.	Width, Meters.	Height, Meters.	Speed, Meters a Second.	Endurance, Hours.	Height Obtainable, Meters.	Passenger Capacity.	Needed for Handling the Airship, Men.
Type A, 4,000..	60	10.4	16.0	20	0.6	1.3	1.2	13	15	2,000	6	3
Type B, 6,000	70	12.3	17.0	22	1.0	2.0	1.4	14	20	2,500	10–12	3 or 4
Type C, 2,000..	50	8.6	14.0	18	6.5	0.8	1.1	11	8	1,000	4	1 or 2
Type D, 1,200..	40	7.7	13.0	16	6.0	0.7	1.0	9	5	600	3	2 or 3
Type E, 3,200.	60	9.4	15.0	19	7.0	1.3	1.2	10	6	1,500	6–8	1 or 2
Type F, 1,000.	45	8.2	12.5	17	5.8	1.0	1.0	8	5	600	3	.....

Types A and B have two propellers and two motors. They are so far, perhaps, the only craft completely immune from failure of the power plant.

The Rumpler Military Monoplane[*]

Everyone knows the tenacity of purpose shown by Germany in the creation of her aerial fleet, which she claims to be the finest in the world. This claim is justified in regard to unity of method, excellence of organization, and number of vessels, but not, at present, by the value of each vessel.

I say at present because Germany has not confined her construction to a particular type, but is now in her third period of evolution in aviation.

At first her principal machines, the only ones able to accomplish a few timid flights, came from French workshops, either bodily and by devious ways, [illegible] of plans obtained by methods which may be [illegible]

The second period was more honorable. The German aeroplanes departed from their French prototypes and assumed an individual character which was first clearly marked in the famous "Taube."

This type possesses undeniable merits, but it is not free from defects, and its performances in other countries, especially France and England, have led to its modifications in Germany. This is the third period.

The progress accomplished in Germany was shown in the last aerial maneuvers, but I will add the statement that the German army will possess nearly 1,500 aeroplanes at the end of the year 1914. Some of these are of the Rumpler type, which is here described.

The body, or fuselage, is trapezoidal in section, and is composed of four longitudinal members, connected by uprights and traverses, and stiffened by stays of piano wire. It rises toward the bow, where a strong frame, resting on inclined struts attached to the under carriage, supports the motor. The bow, including the pilot's compartment, is covered with sheet aluminium. The rest of the body, which tapers toward the stern, is covered with canvas.

The wings, like those of the "Taube," have nearly the form of pigeons' wings. In the original Rumpler type,

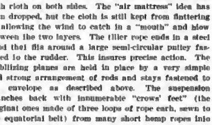


Fig. 1. Improved Rumpler "Taube" military monoplane, 1914 model. The pilot, Linnekogel, is standing on the wing.

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[*] Translated from Henri Mirouet's article in *L'Aérophile*, August 1, 1914.

the wing is supported principally by a truss, the bottom chord and uprights of which are visible in the diagram (Fig. 2). Additional support is given to the wing by the front and rear beams of the wing frame. The ribs of the rigid part of the wing are made of ash, the flexible tips of corded bamboo. The wings are stiffened by interlacing wires and by stays attached to the cabane above and the undercarriage below.

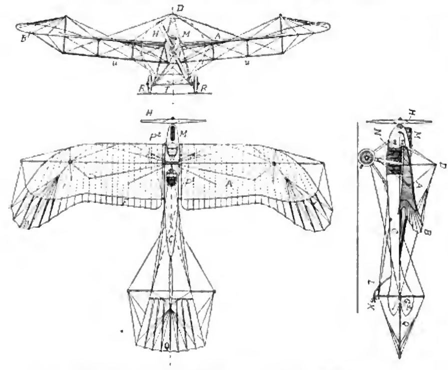


Fig. 2.—The Rumpler monoplane. Original model with flexible wing tips.

A, wing; *B*, flexible tip; *C*, fuselage; *D*, cabane; *E*, reservoir; *F*, flexible rear part of wing; *Gd*, rudder; *H*, propeller; *K*, brake shoe; *L*, skid; *M*, motor; *N*, radiator; P^1, pilot; P^2, passenger; *Q*, flexible elevator; *R*, landing wheels; *S*, foot tiller; *T*, axle of landing gear; *U*, wing truss; *V*, warping wheel and elevating lever.

The general stability of the machine is assured by the form and the flexibility of the wings. In the original Rumpler type this stability involves a certain sluggishness of control. We shall see, presently, how this defect has been removed.

The lateral stability is intrusted to the flexible wing tips. For this purpose each tip is attached to a wire, and these wires terminate in a "goose-foot" pivoted to the end of the supporting truss.

The longitudinal stability is assured by a fixed triangular horizontal plane, prolonged to form a flexible tail, which is attached and flexed similarly to the wing tips. The vertical rudder is double, and turns on a stern-post at the extremity of the body.

The landing gear is very strong; and the fuselage rests on its two principal uprights, which are reinforced by two pairs of inclined struts, of which the front pair supports the motor and the rear pair supports the rear end of the body. The two wheels turn freely on a fixed axle, provided with springs. The after part of the machine is supported, when on the ground, by a skid provided with springs and with a brake-shoe, under the control of the pilot.

Warping is effected by turning a wheel, elevation and depression by moving a lever backward and forward, horizontal steering by moving the usual transverse foot bar. The propeller is coupled directly to a fixed Mercedes motor of 100 horse-power. The reservoirs are fitted beneath the passenger's seat, and the radiators are placed on each side of the fuselage.

The sluggishness of control exhibited by this original Rumpler type is remedied in the new model (Fig. 1), in which the wings themselves are not flexible. They have flexible tips, or ailerons, however. Furthermore, the supporting truss has been done away with beneath the wings, which are made with heavy I-beam longitudinals, such as are used in most monoplanes.

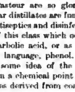
The results obtained by these improvements are very satisfactory, as was proved in Linnekogel's attempt to surpass the record of height. The new type has greater horizontal and ascensional speed than the old one, and is more easily controlled. Hence, it will probably be adopted instead of the original Rumpler model.

Coal Tar Products in Medical Use

A Review of the Important Developments of an Extensive Class of Compounds

THERE has been a good deal of discussion, during these days of the European war, regarding the coal tar product industries which have reached such a wonderfully flourishing condition in Germany. The center of interest has perhaps been taken up by the dyestuffs industry, which has received its share of attention by us on another page. Another phase of the coal tar industry, the application for medical purposes of various products derived from the dry-distillation of coal and allied substances, is discussed by Dr. Georg Wolff in the German periodical *Technische Monatshefte*.

The writer points out that the important developments in the medical employment of coal tar products date from the time of the discovery of antiseptic and aseptic methods in medicine and surgery, with which the names of Lister and Pasteur are so gloriously linked. For among the coal tar distillates are found some of the chief of our modern antiseptics and disinfectants. Perhaps the first substance of this class which occurs to the mind of the layman is carbolic acid, or as it is called in more strictly technical language, phenol. It may be well to give the reader some idea of the general type which characterizes from a chemical point of view, a numerous class of substances derived from coal tar, and known to the chemist as aromatic or benzene compounds. Phenol is a typical example of this class, being very closely related to the fundamental substance, benzene. This latter is a compound of carbon and hydrogen, containing six atoms of each in the molecule, so that its formula C_6H_6. For reasons which cannot be explained here, the chemist regards the six carbon atoms of this molecule as being linked together in the form of a hexagon, each carbon atom having a hydrogen atom attached to it after the manner shown below.



Each of the hydrogen atoms is capable of being replaced by a great variety of elements or combination of elements, and thus a vast number of so-called benzene derivatives are obtained. One of the simplest of these is phenol or carbolic acid already mentioned. It differs from benzene in that one of the hydrogen atoms is replaced by the hydroxyl or OH group, which is formed of one atom of oxygen and one atom of hydrogen. There are also substances known as cresols, which contain, in addition to the hydroxyl group, the so-called *methyl* group, CH_3. There are three of these, as the hydroxyl and methyl groups may be attached to adjacent carbon atoms in the hexagonal benzene nucleus, or two alternate carbon atoms, or yet again to two diametrically situated carbon atoms. These three cresols are distinguished in chemical terminology as respectively ortho, meta, and para cresols. We shall have occasion to refer to them again later.

As regards coal tar itself, Dr. Wolff remarks that this does not, to-day, find much use in medicine. He goes on to say: "Somewhat more generally employed are certain kinds of wood tar made by the dry distillation of the wood of juniper, beech, birch and fir. While coal tar is alkaline in reaction owing to the presence of ammonia and allied bases, the wood tars are acid in reaction, owing to the presence of acetic (pyroligneous) acid and its allies. These wood tars are also rich in phenols and aromatic hydrocarbons. Wood tars have long been used in treating skin diseases. Of recent years they have largely been displaced by coal tar products, such as naphthene, resorcinol, ichthyol, etc., concerning some of which more will be said presently. There is still a third kind of tar, which in the past has found use in medicine, namely so-called animal tar, prepared by distilling various waste products such as bones, horns, hoofs, etc. This highly malodorous product used to be prescribed as a remedy for asthma. Fortunately, better and less repulsive medicaments are known to modern medicine.

"A distant relative of animal tar is the ichthyol of which mention has just been made. This is obtained by the dry distillation of bituminous shale containing fossil fish remains. The ammonium salt of the oil, after treatment with sulphuric acid, contains 10 per cent of sulphur and is much valued in combating such skin disorders as eczema. Now the fossiliferous shales are unfortunately scarce and efforts have therefore been made to prepare an artificial substitute for ichthyol. By heating coal tar products with sulphur at a high temperature the substance known as thiol is obtained which has found somewhat similar use as ichthyol. Tar sulphur soaps owe their efficacy partly to the disinfecting qualities of the tar, and partly to its property of causing the skin to scab off. There may also be a slight local anesthetic action which relieves itching."

Passing from the consideration of the comparatively crude coal tar products, Dr. Wolff then goes on to the discussion of a class of definite chemical compounds, some of which are isolated from coal tar by distillation, while others are prepared by definite chemical processes.

"Among these are the phenols already mentioned and such substances as salicylic acid, benzoic acid and others. As regards the action of these upon the human organism, certain general statements can be made. They are antiseptic, as already noted, that is to say, they tend to arrest the growth of bacteria, and what is more important, they have this effect upon bacteria without at the same time equally injuring the human organism. They are also antipyretic, that is to say they reduce the temperature in fever cases. This is especially true of salicylic acid. A peculiarity of the benzene derivatives which contain the hexagonal nucleus spoken of above, is that they pass through the body with that nucleus unbroken, that is to say they are not, like most carbon compounds taken in with the food for example, oxidized completely to carbon dioxide and water.

"Benzene itself, the parent substance of the aromatic compounds, finds little use in medicine. Its near ally, naphthalene, which is built up of two hexagonal nuclei linked together, has the peculiarity of being highly poisonous for lower animals, while being comparatively harmless to man. For this reason it is a familiar household remedy against insects, moths, etc., and has also a field of usefulness in medicine in dealing with parasitic troubles.

"The simplest phenol, that known in the trade as carbolic acid, is not now used quite as extensively as in former days. It used to be the regular standby of the physician in the operating room. While its use for applications of this character has not ceased entirely, it now finds its principal employment for cruder purposes of disinfection, and the cresols have in a measure superseded phenol as an antiseptic.

"Among the cresol preparations, a drug known as Lysol is particularly valuable. It is made from equal parts of cresols and soft potash soap. The addition of the soap merely serves the purpose of making the cresols soluble in water. Without such addition they are only very slightly soluble. The cresols, which differ from phenol by the addition of a methyl or CH_3 group, as has been explained above, have the advantage of being somewhat stronger antiseptics, and at the same time less poisonous than phenols. Nevertheless they are not entirely non-poisonous, and unfortunately cases are on record of Lysol having been used by suicides.

"There are also phenols containing two or more OH groups attached to the benzene nucleus. Thus, for instance, the well-known photographic developer hydroquinone is para-hydroxy-benzene, that is to say it is derived from benzene by the substitution of two diametrically opposed hydroxyl groups in the hexagonal nucleus. This substance is not used in medicine, but its close ally resorcinol, the corresponding meta-compound, is used in the treatment of skin diseases owing to its solvent action upon the skin. Another drug used for similar purposes is the tri-hydroxy-benzene known as pyrogallol or pyrogallic acid to photographers. The hydroxy compound of naphthalene also, naphthol, is used as a medicament for the skin. To be quite exact there are two naphthols, distinguished as alpha and beta naphthol, which differ in the position of the hydroxy group in the naphthalene nucleus, and only the latter of these two finds medical application. It has to be used with some caution as it has a peculiar property of being very readily absorbed by the skin, and if used in too large doses it is apt to unfavorably affect the kidneys.

"Another important tar product is creosote, which is not a single chemical individual, but consists chiefly of guaiacol and creosol, compounds of rather more complicated structure than the phenols. Creosote resembles in its action the phenols, but has been found adapted to internal use, and forms one of the stock remedies in the treatment of consumption. It was at first supposed that it exerted some degree of germicidal action upon the tubercle bacilli. This view is hardly held by any authority to-day, although creosote does seem to exercise beneficial action in cases of tuberculosis, probably owing to secondary causes.

"Of the simple acids closely allied to benzene we may mention three as of medical importance. Benzoic acid, structurally the simplest of all aromatic acids, used to be administered in cases of gout. This use is practically discontinued at the present day, and benzoic acid is now prescribed only as an expectorant in bronchial catarrhs and similar affections.

"A more complicated acid is cinnamic acid, closely allied to the characteristic ingredient of cinnamon. Of late, this has been prescribed against consumption. It is also the essential ingredient of Peru balsam which is used in contending with some very disagreeable skin parasites.

"The most important, however, of the simpler acid derivatives of benzene is salicylic acid, which is closely related to benzoic acid, differing from it by the presence of a hydroxyl group attached to the benzene nucleus. Salicylic acid owes its name to the source from which it was first derived, namely willow bark, the Latin name for willow being *salix*. Willow bark has been known from antiquity as a febrifuge. Salicylic acid has three medically useful properties. Like most of the compounds of its class it is antiseptic in its property, and lowers the body temperature. In addition to this it has been found a very excellent drug for the treatment of acute rheumatism of the joints. By combination with other substances, salicylic acid has been made the source of numerous other products, of which only one or two shall be mentioned here. The substance known as salol is a combination of salicylic acid with phenol. A compound of salicylic acid with acetic acid is known as asperin, a household remedy for headaches, rheumatic pains, etc."

Following Dr. Wolff, we have here taken a brief survey only of some of the simpler coal tar products which have found a place in the doctor's medicine chest. The industry of synthetic medicine has in recent years been developed with great skill and with much success. To give an adequate presentation of what has been accomplished in this field would, however, require the introduction of complicated formulas and uncouth technical terms, such as delight the organic chemist. We shall therefore rest content with this survey of the simpler coal tar products employed in medicine.

Honoring Napier

On July 24th a celebration was held at Edinburgh in honor of John Napier, the inventor of logarithms, and the following notes on the occasion, and from the remarks of the speakers, are from a recent issue of *Engineering*, London.

Three hundred years ago there appeared a small quarto volume, "Mirifici Logarithmorum Canonis Descriptio," whose influence upon the development of mathematics it is difficult to overestimate. It was the first set of logarithm tables, and was the evidence of a new thought and a new power, destined to revolutionize arithmetical calculations.

In teaching his generation how to construct tables of logarithms, he devised an artifice that with accuracy and facility solves a number of problems that previously could be dealt with only by the expenditure of much time and the cumbrous method of simple arithmetic. It was a great achievement, only possible to a profound thinker; but it is so easy to turn up a table of logarithms that we forget the labor involved in forming the first. We appreciate as little the industry and patience needed as we do the clearness of thinking and the training required to take a new step in a direction in which there are no pioneers.

Though logarithms figure mostly as an instrument for facilitating calculation, that is not the form in which the problem presented itself to the inventor. A far more general principle engaged his attention. He sought to determine the motion of a point which moved in a straight line with varying velocity, the velocity being proportional to the distance of the moving point from a given point. He asked what was the length of the line passed over in each case in equal increments of time, and in that way was led to perceive the relation between two series of numbers—one increasing in arithmetic progression, the other in geometric. Doubtless to Napier there appeared no other way of approaching the subject. But there are widely different methods of arriving at the same truths; for in mathematics, more often than in other branches of science, it has been shown that results which seemed so remote and concealed that they could only be successfully attacked in a certain direction, prove to be singularly simple when viewed from another standpoint.

The principal address was made by Lord Moulton, himself a distinguished mathematician, who devoted himself in his remarks rather to an analysis of Napier and his methods. Every fact known about Napier, said Lord Moulton, had become commonplace. They were all aware when he was born and when he died; that he wrote at length on the Apocalypse; that he was suspected of trafficking in black magic, etc. What was known left the man very imperfectly disclosed, but sufficed to show him strong and self-reliant, of solitary habits, and of profound and untiring industry.

There was, however, one aspect, as it appeared to Lord Moulton, in which he might perhaps find something to contribute, even though it should prove but a widow's mite. The invention of logarithms came on the world as a bolt from the blue. No previous work had led up to it; nothing had foreshadowed it or heralded its arrival. Did this come as a revelation to Napier, bursting upon him as a light from heaven, or was it the result of a slow growth, the evidences of which were now obliterated? The undoubted fact is that Napier worked for some twenty years at logarithms before he published his first book relating to them. It must have been a slow and gradual evolution, even though that which remained furnished so few traces of the earlier efforts. Was it then possible from the records left, and out of the circumstances of the time, to read the history of this evolution, to reconstitute the process of discovery by deciphering the half-effaced records of this growth? It was in this direction that something of interest might be found.

Lord Moulton then proceeded to discuss the question, What set Napier to work on the lines he did, seeing that there was no antecedent work to suggest a plan, and to indicate what were probably the different stages of the discovery? It was urged with increasing probability that Napier, seeing that trigonometrical tables enables a product to be found without actual multiplication, conceived the idea of constructing special tables which would do the same work in a more thorough and expeditious manner; it was probable that originally Napier contemplated nothing further than repeated multiplication by a factor near to unity, so that each multiplication reduced, very slightly, the number operated upon, and that the word "logarithm," signifying "the number of the ratio," preserved that idea. In the second stage of the discovery, the notion of multiplying by a factor gradually gave way to the idea of taking an aliquot part from the number arrived at by the preceding operation, and that this thought led Napier to pass from the idea of figures to the geometrical representation of the quantity by a line, and to find that his repeated operations were perfectly repeated by cutting off the same fraction of the same diminished length. Further, that at this stage Napier took the simple and obvious step which ultimately proved of momentous importance, completing his discovery, and putting him in a position to commence the calculation of tables.

Another speaker who addressed the meeting was Dr. J. W. L. Glaisher, who contended that, as a product of the time, the conception of logarithms in Napier's mind was little short of marvelous. He had no notation such as they had now to guide him, and in mathematical development a good notation was of primary importance. As regards arithmetic notation, it would appear that Napier was the first to use the "point" in expressing decimal fractions, a notation far superior to that devised by Stevinus, and widely used even in Napier's day. The more they examined the method of Napier the more were they impressed by his greatness.

Prof. Eugene Smith of New York read a paper on "The Law of Exponents," as illustrated in the works of the XVI century. The nature of the geometrical progression and its correspondence with a parallel arithmetic progression was traced through the works of Chuquet, 1484, and Boethius, 1490, to the writings of Rudolff, 1525, and Stifel, 1544, to those of a later date. It was this line of development which influenced Burgi, whose "Progress Tabulen" contained what was an antilogarithmic table. The importance of these arithmetical relationships, clearly conceived by the Teutonic school, was recognized by Cardan. These relationships approach so closely the idea of the logarithm, that it was a cause for wonder that the works of Napier and Briggs were not anticipated.

Remarkable Deflections of the Plumb Line in Northern India

Deflections of the plumb line of a remarkable character have been discovered at points near the southern border of the Himalayas, and these are considered by R. D. Oldham in the Royal Society *Proceedings* and the geological structure of the region is discussed. The known geodetic facts are that along the southern edge of the Himalayas very high northerly deflections, amounting to about 40 seconds of arc, are found, which rapidly decrease in a southerly direction by about 30 seconds in as many miles, after which they become much more gradual. Northerly also there is a decrease, though not so rapid as to the south. Burrard's hypothesis, in explanation of these facts, is the existence of a belt of deficient density, of considerable depth, but of no great width, along the southern edge of the Himalayas. As this rift is on a scale of magnitude far in excess of anything for which there is geological precedent, the author has been led to investigate whether some other explanation was possible more in accordance with geological observations. The geological structure is as follows: Along the southern edge there is a great fault separating the older rocks of the range from the upper tertiary, Siwalik beds, which Medlicott showed to have been formed under conditions similar to those of the recent deposits in the Gangetic depression, and to be the lower, marginal deposits of the same continuous formation, of which the Gangetic alluvium forms the uppermost members. The depth of this formation along the northern margin is certainly great, nowhere less than 10,000 feet, and possibly 30,000 feet in places. On the southern margin the thickness is small, and the deposit thins out over an old land surface of rock. Between these two limits it is natural to suppose that the depth of the alluvium decreases gradually from north to south, and its mean density has been taken at 2.1, the mean density of the rock forming the sides and floor of the depression being about 2.7. It is the effect of this large bulk of material, having a density of only about seven ninths of the average density of surface rock, which has been investigated. The method adopted was based on Hayford's system of compartments, the trough being assumed to run east and west, with the deep side on the north, and divided into belts of ten miles wide, running parallel to the margins, in each of which the depth was assumed to be uniform and equal to the mean depth of the belt. The data obtained are subjected to the necessary corrections, and the general conclusions to be drawn appear twofold: (1) that the local deflections of the plumb-line, produced by underground topography, along the region bordering the southern margin of the Himalayas, are of such magnitude as to make the observations, at stations situated in that region, of small geodetic value, unless allowance is made for the invisible, as well as the visible, topography; and (2) that there is no geodetic justification for the assumption of the existence of a deep and narrow rift, filled with material of lesser density than the rock on either side, or for any modification of the deductions, regarding the form of the floor of the Gangetic depression, which have been drawn from geological observation.

Agronomic Institute.—The National Agronomic Institute of France, which is located at Paris in the University quarter, is at present in a flourishing condition, this being evidenced by the considerable extension which is being made to the building, and it will be at least doubled in space. The new portion is expected to be completed in the near future, and like the former it will house various laboratories and other quarters connected with agronomic work. Prof. Regnard, an eminent scientist, is at present at the head of the institution.

The Physiological Standardization of Drugs

How the Strength of Drugs is Determined and the Proper Dose Found

By Lewis Davis, M. S.

IT is a curious fact that, to the average person, all medicinal agents are shrouded in a veil of mystery. Take the term "drug," for example, and it unconsciously brings to the lay mind the childhood conception of the simmering pot in the deep wood filled with strange roots and herbs, and attended by the witch with her peaked hat and crooked staff. Only to such hardy adventurers as the physician and the pharmacist has been left the task of penetrating this maze. The ordinary mortal is content to escape by heroically taking doses of bitter-tasting "medicines" in his illness, or stoically submitting to hypodermic injections, regardless of the origin or value of the material employed.

Fortunately, science does not share in this attitude. Careful investigation has not only succeeded in establishing the composition and therapeutic action of many drugs, but has set up certain standards of activity to which they must conform. The modern physician no longer prescribes drugs, trusting to good fortune that they contain a requisite amount of active principle. These have all been assayed in the laboratory by their actions on test animals with a degree of delicacy far surpassing the most refined chemical or physical means. When it is considered that 0.00002 gramme of the active principle of Strophanthus seeds will cause the death of a test frog weighing one million times that amount (20 grammes), the extreme sensitiveness required of a suitable method of standardization is readily apparent. In fact, chemical methods of testing are not only by far incapable of such extreme delicacy, but are more usually of no value.

It might be well to ask, what are these substances—drugs—which are so highly potent in their effects? A popular definition of a "drug" might be given as any substance—animal, vegetable, or mineral—used in the preparation of medicine, or in the cure of disease. This would include chemicals, the alkaloids, vaccines, serums, certain gland products, and finally, those plant substances of undetermined chemical nature which are capable, upon introduction into the body, of producing certain distinct effects. Properly speaking, it is these last two products—the gland materials and plant derivatives—which should be designated as "drugs."

While the plant derivatives, particularly the heart tonics, have been known to the scientific world for decades, our knowledge of the gland products and their actions has all come to us within the past fifteen years. Two of these, in particular, command our attention—products from the suprarenal gland and those from the pituitary gland.

Surmounting each kidney usually, or lying very close to it, we find the right and left adrenal glands, the latter being usually the larger. They differ in shape from each other, and the right capsule having a flattened triangular form, the left a crescent shape. There are also variations from these forms. In the human they weigh about four grammes and are nearly as large at birth as in adult life. In color they are dark red, or sometimes yellowish red. One or both capsules may be absent, although this is rarely the case.

The glands are smaller in advanced age, and it is said that negroes have larger ones than Caucasians, which fact no doubt bears some relation to the pigmentation of the skin.

When sectioned, they are seen to consist principally of two parts, an outer firm portion (cortical), and an inner (medullary) part which is soft and pulpy. These parts are usually quite definitely marked, but it is difficult to separate them perfectly since they are more or less closely "dove-tailed" into each other.

Removal of the suprarenal bodies in animals is speedily followed by symptoms of extreme muscular prostration and within a few days by death. For years a puzzle to the physiologist and physician, it came as a surprising discovery that some of the constituents of the suprarenal

Fig. 1.—Foxglove.

Fig. 2.—Ergot in rye.

Fig. 2a.—Indian and American Hemp.

Fig. 3.—Lily-of-the-valley.

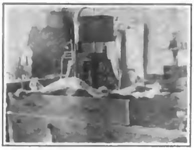


Fig. 5.—Dog connected with kymograph as used in assaying adrenalin and pituitary extracts.

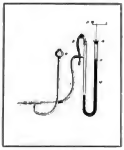


Fig. 5a.—Recording mercury manometer and canule.

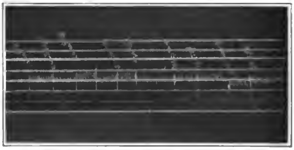


Fig. 8.—Tracing made by the kymograph, showing rise and fall of blood pressure, due to adrenalin chloride solution.

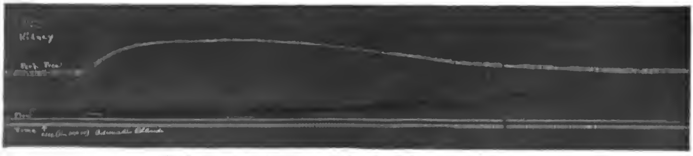


Fig. 10.—Tracings obtained with kymographion of Fig. 2 in testing unknown samples.

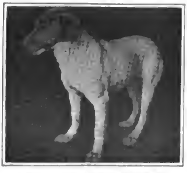


Fig. 4.—Dog showing characteristic intoxication of cannabis.

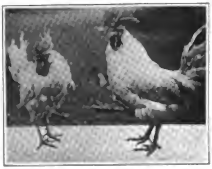


Fig. 6.—Roosters used in testing strength of ergot.

Fig. 7.—Testing the strengths of the heart tonics by their actions on frogs.

gland had a remarkable influence upon blood pressure. Few discoveries in medicine have been of greater importance than the announcement in 1897, that the suprarenal gland contained a certain substance which had the wonderful power of lessening, or even preventing, hemorrhage by virtue of its local or constricting action on the blood vessels. In other words, here is an agent at the command of the physician which diminishes the flow of blood by simply, so to speak, "stopping it up." As would be expected, extracts and various products of this gland soon came into use for producing bloodless operations in eye and other delicate branches of surgery, for the prevention of hemorrhage, and for increasing the blood pressure. Careful scientific investigation has resulted not only in the preparation of the active constituent of the gland in a chemically pure form, but more recently a synthetic product has come upon the market, identical in all its remarkable properties with the natural product obtained from beef.

The natural material, known under various names, as "adrenalin," "suprarenin," etc., is, when pure, practically white in color, and composed of microscopic crystals of various forms. These chemically pure crystals (of "adrenalin") serve as a standard for the assay of products of the suprarenal glands, and the strength of any product is stated in terms of the standard—as, for example, "Solution of Adrenalin" 1–10,000, etc.

Although very recently a chemical method has been proposed for the assay of adrenalin and similar products, the physiological method is used almost entirely. Various animals may be used for this purpose, but the best results are obtained with medium-sized dogs.

The physiological determination of the strength of products from the suprarenal and of the pituitary glands—these latter substances will be discussed later—is almost identical. The method depends upon the fact that when properly diluted doses of these drugs are injected directly into the circulatory system of test animals (dogs) there is produced a definite, characteristic rise in the blood pressure of the animal which soon comes back to normal. The test animal is first anæsthetized completely, after which the hair is clipped from the throat and the tissues severed. A glass "cannula," as it is called, or connecting tube of suitable size is now tied in the common carotid artery, which, in turn, is connected with a tube filled with sodium carbonate (soda ash) or other solution, to prevent the blood from clotting. The latter tube is attached to a manometer or "U" tube containing mercury. A schematic representation of a recording mercury manometer and its connection with the artery is shown in Fig. 5a. *C* represents the "cannula" which is inserted in the artery previously clamped. On releasing the clamp, the pressure of the blood is communicated through the liquid in *t* to the column of mercury in the manometer *M*, until the weight of the column which is forced up, shown by the difference in level between 1 and 2 counterbalances the pressure of the blood. The limb of the U tube in which the mercury rises carries a float (*f*) of aluminium, hard rubber, or some other substance lighter than the mercury. This float, in turn, carries a stiff wire which plays through an opening in the cap (*G*) of the tube. The free end of this wire bears a needle (*P*) or more usually a bent metal arm, which marks a tracing on a revolving sheet *S*. The latter may be plain, white, or sensitized paper, but is more often smoked paper, and the record scratched out by the metal pen.

Such a complete recording apparatus, known as the "kymographion," and its connections to the test dog are shown in Fig. 5, as used in a large commercial laboratory for the routine standardization of products from the suprarenal and pituitary glands. The method, in brief, is as follows:

A definite quantity of the standard solution is injected into the femoral vein (Fig. 5), and with the kymographion in motion, the maximum rise in blood pressure is communicated through the tube *t* and recorded on the revolving sheet (*s*). The pressure is now allowed to return to normal, after which, varying amounts of the solution are similarly injected until the resultant increase of pressure as recorded by the needle is equal to that produced by the known amount of the standard. For example, if it takes three cubic centimeters of the unknown to produce the same rise in blood pressure as that caused by one cubic centimeter of the standard, then the sample is said to be "33⅓ per cent of standard," etc. A tracing of this sort is shown in Fig. 10, while Fig. 8 shows the sudden rise and slow return of pressure due to an injection of adrenalin chloride (1 in 100,000 parts).

As already mentioned, the usual method of standardizing extracts of the pituitary gland is identical with that described for adrenalin. The pituitary body or "hypophysis cerebri" as it is scientifically termed, is even a greater mystery than the suprarenal glands.

Hidden away in the very middle of the skull in a little bony cup (sella turcica), better protected than any other gland in the body, and very inaccessible, is the little body known to anatomists as the pituitary body, believed for a long time, until 1886, to be void of all physiological value, in fact, a sort of useless appendix of the brain. Some of the older writers ascribed to it the function of secreting mucus, hence the term "pituitary body"; others ascribe to it manifold functions. In the human and in sheep it weighs about 0.5 grammes, in cattle 2.5 to 3 grammes. In shape it is oval, and when fresh it has a pinkish color.

Fig. 9.—View of laboratory fitted for drug standardization.

If we were to section the pituitary gland, we would see plainly two definitely marked parts, but histologists tell us that it is composed of three parts—anterior, posterior and intermediate. It is usually described as consisting of two parts—the larger or "anterior lobe," and the much smaller "posterior lobe." The "posterior lobe" arises as an outgrowth from the floor of the brain and it is this portion which contains physiologically active substances of considerable therapeutic importance. The active principle, known as "pituitrin," "hypophysin," etc., also has the power of raising the blood pressure similar to that of adrenalin, but to a more marked degree. In addition, it has the remarkable property of causing contractions of the uterus, and within the last few years has come to be of great assistance during child-birth, in cases of uterine insufficiency. The drug has also the power of stimulating the secretion of urine and especially of milk.

Disturbance of the pituitary due to disease or otherwise may bring about the conditions known as "acromegaly" and "gigantism." In the former case there is an enlargement of the bones of the face and extremities, while in the latter there is an overgrowth in the whole skeleton.

Both in pituitrin, but particularly so in adrenalin, there is a more or less clearly defined active principle upon which the physiologic assay can be based. There are, however, two very important drugs which have no such constituent that can be utilized to base a method upon. These are ergot and cannabis.

Under certain conditions rye may become affected with a black smut or fungus growth which is known as the "ergot" of rye (Fig. 2). Almost all of the ergot of commerce comes from Russia and Siberia. Aside from its use to stimulate the heart and to increase the blood pressure, the alcoholic (fluid) extract of the drug is employed to assist contractions of the uterus in child-birth in the same way as pituitrin.

Considerable research on the subject has failed to bring about any agreement as to the active principle or principles of the drug. Blood pressure experiments gave too variable results to be relied upon, while its contraction of the muscle of the uterus also proved unreliable. Not baffled by this, the pharmacologist has cast about and found the desired subject in our shrill announcer of the dawn—the rooster. The physiological testing of ergot depends upon a characteristic blackening or blanching which it produces in the comb and wattles of selected cocks, when the drug or its preparations are internally administered in suitably sized doses.

The test fowls are normal, thoroughbred, white Leghorn cocks, twelve to eighteen months old, which have been allowed to fast for twenty-four hours. The animals should not be used for a longer period than six months, and not oftener than once a month. The standard used is a fluid extract of the drug, made up according to the "U. S. Pharmacopœia," and which by repeated tests has been shown to possess the average activity of, at least, ten samples of first class, commercial ergot. The alcohol in both the standard and the unknown samples is removed by evaporation, and both converted into as nearly the same condition as possible. The alcohol-free samples were formerly introduced into the crops of several of the test fowls through a soft rubber tube in doses of 15 cubic centimeters per kilo of body weight. Now, however, it is more usual to inject a smaller dose directly into the breast muscle. By varying the size of dose and repeated trials, the amount of the unknown is determined which will produce the same degree of blackening in the parts as the test dose of the standard. (See Fig. 6.)

Very rarely is intoxication induced for such a worthy purpose as in the standardization of cannabis. "Cannabis Sativa," or, as it is better known, "Indian Hemp," is extensively employed in the treatment of insomnia, neuralgia, headache and hysteria. The dried, flowering tops of the plant are used, and careful investigation has shown the domestic variety of the drug, "American Hemp," to be fully as efficient as the imported product from India.

The active constituents of Cannabis are even less understood than in the case of ergot, consequently chemical standardization is out of the question. Here again, a physiological method is made use of, with healthy, medium-sized, short-haired dogs, young, but full grown, as the test animals. The standard used is a U. S. Pharmacopœia extract of cannabis having the average activity of not less than ten samples of first-class, commercial drugs, and the standard test dose is 0.010 gramme per kilo body weight.

In testing, at least two dogs, susceptible to the drug, are used, one of which receives the standard, and the other the unknown sample. These are administered internally in a small capsule by drawing the dog's tongue forward between the teeth with the left hand, and placing the capsule on the back part of the tongue with the right hand. On quickly releasing the tongue, the capsule is swallowed with ease. To aid in absorbing the drug, the dogs are usually allowed to fast for twenty-four hours before the test.

Active extracts when administered to susceptible animals show three typical effects: First, excitability, then a period of incoördination, followed finally by drowsiness. The second stage of incoördination usually follows in one to two hours; the animal loses control of its legs and of the muscles supporting its head. If nothing occurs to attract the dog's attention, which is absolutely essential, the head will drop, the body sway, and when severely affected, the animal will stagger and fall, the intoxication being peculiarly suggestive and striking. (See Fig. 4.)

The influence of the test dose of the unknown drug is carefully compared with the same dose of the standard administered to another test dog at the same time and under the same conditions. When the animals become drowsy, the observations are recorded and the second day following, the two dogs are reversed. The animal previously receiving the test dose of the unknown now receives the test dose of the known, and *vice versa*, a second observation being made. From the dose of the unknown, selected as producing the same action as the test dose of the standard, the amount of dilution or concentration that is necessary is determined.

It would hardly occur to the average reader that aside from its epicurean possibilities the frog forms one of the most delicate testing instruments at the disposal of the scientist. Yet it is an actuality that only by careful tests on frogs is it possible to assay the strength of those drugs known as the "heart tonics of the Digitalis Series." These drugs, of which the lily of the valley or convallaria, the fox-glove or digitalis, squill and strophanthus are the most important members, have a special affinity for the heart muscle tissues and are very active poisons. The active principles of all of the drugs are so very much alike that they may be considered as one group and may be physiologically assayed by the same method. They differ greatly, however, in the amount of their activity and in their poisoning powers. It is precisely this poisoning power, particularly with cold-blooded animals, which is made use of in determining the strength of these drugs. Briefly, the method of administering these poisons and of observing results is as follows: (Fig. 7.)

The drug, or its tincture, is dissolved in salt solution of the same strength as that found in the body fluids. By means of long, slender, glass measuring tubes or "pipettes," having a hypodermic needle attached, accurately measured amounts are now injected directly through the frog's mouth into the abdominal lymph sac.

As a rule, it is necessary to inject several series of about five frogs each for each sample of the drug to be tested. The first series is injected with a standard tincture of strophanthus made up according to the U. S. Pharmacopœia. Usually 0.00015 cubic centimeter per gramme body weight of frog is found to be the smallest amount of this drug which kills the frog, or, as it is known, its "minimum fatal dose" (M. F. D.). The second series is now injected with doses of the unknown varying considerably in size.

After the approximate dose of the poison has been found from the second series, a third series is injected to fix the minimum fatal dose. Finally, a fourth series is injected which fixes the limits of strength very closely. In a good test, the minimum fatal dose in the fourth series should kill at least three frogs out of five. Now, by comparing the minimum fatal dose of the standard with that of the unknown, a certain ratio is obtained, as 1¾, ¾, etc.

It is usual to express the strength of this series of drugs in terms of "heart tonic units" (H. T. U.), the heart tonic unit being ten times the minimum fatal dose per gramme body weight of the frog. The standard tincture of strophanthus has been found to contain 650 heart tonic units. To give the strength of the unknown drug, all that is necessary then is to multiply the above ratio of the minimum fatal doses by 650 to get the number of H. T. U.'S (heart tonic units) the drug contains in every cubic centimeter.

Heat; A Lecture for Beginners*

An Explanation of Terms and Principles Necessary to Understand Engineering Problems

By Charles H. Bromley

As THE boiler is a combined heat generator and heat absorber, an understanding of what the unit of heat is, is essential to a thorough understanding of boiler operation. Heat is a form of energy for which there are numerous explanations, but they are of little practical value to the power-plant man. One of the most essential things for him to know is that the standard quantity or unit of heat in general use in this country is the *British thermal unit* (abbreviated B.t.u.). In practice, this *quantity* is usually considered as that amount of heat required to raise *temperature* of water 1 deg. Fahr.

TEMPERATURE.

While the B.t.u. is the *quantity* of heat, the temperature indicates the *quality* of heat. One hundred pounds of water at 100 deg. Fahr. contains more heat than one pound of water at 200 degrees. One body of water is twice as *hot* as the other, but it did not take as much heat to make it that hot as it did to make the larger body one half as hot; see Fig. 1. Remember that temperature indicates only *how hot* a body is; it does not tell directly *how much heat* there is in it.

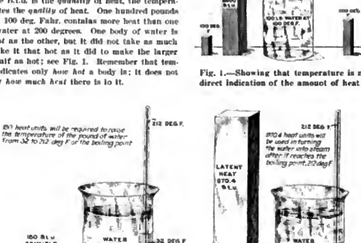

180 heat units will be required to raise the temperature of the pound of water from 32 to 212 deg F or the boiling point
212 DEG F.
100 B.t.u SENSIBLE HEAT
WATER 1LB
32 DEG F
LATENT HEAT 970.4 B.t.u
212 DEG F.
970.4 heat units will be used in forming the water into steam after it reaches the boiling point, 212 deg F
WATER 1LB
POWER

Fig. 2.—Showing the relative amounts of sensible and latent heat needed to boil a pound of water into steam at atmospheric pressure.

Pressure, of course, has a good deal to do with heat and temperature as related to water. For instance, as seen from Fig. 1, there is much more heat in the 100 pounds of water at 100 deg Fahr. than there is in the one pound of water which is at 200 deg. Fahr. Suppose we had the one pound of water under 400 pounds absolute pressure, that is, the pressure as indicated by the gage plus the pressure of the atmosphere or 15 pounds; the temperature would be 444.8 deg. Fahr. The one pound of water would contain 1,208 B.t.u. at this temperature—over seven times as much as when heated to 200 deg. Fahr.

THERMOMETER SCALES.

The measurements of temperature as we make them are arbitrary. They are made to suit our convenience, as shown by the three standards in use; the *Fahrenheit* scale, which is mostly used in engineering calculations in America, and the British Isles, and according to which water freezes at 32 degrees and boils at 212; the *Centigrade*, used universally, on which the freezing point is 0 degree and the boiling point 100, and the *Reaumur*, where the freezing point is 0 degree and the boiling point 80 degrees. We see then that

1 deg. Fahr. = $\frac{5}{9}$ deg. Cent.
1 deg. Fahr. = $\frac{4}{9}$ deg. Reaumur.

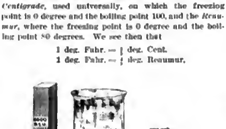

100 DEG F
100 LB WATER AT 100 DEG F.
1 LB WATER

Fig. 1.—Showing that temperature is not alone a direct indication of the amount of heat in a body.

so that to express the different scales in terms of one another we have:

Fahrenheit degrees − 32 × $\frac{5}{9}$ = Centigrade degrees.
Fahrenheit degrees − 32 × $\frac{4}{9}$ = Reaumur degrees.
Centigrade degrees × $\frac{9}{5}$ + 32 = Fahrenheit degrees.
Reaumur degrees × $\frac{9}{4}$ + 32 = Fahrenheit degrees.

ABSOLUTE TEMPERATURE.

Put a cake of ice in a room where the temperature is 20 degrees below zero and the ice will eventually cool off until its temperature is the same as that of the room; the ice will *give up heat* to the air in the room. We see then that, although ice forms at zero degrees on the Centigrade scale, this is not the lowest temperature that a body may attain; it is not the temperature at which there is a *total absence of heat*, not *absolute zero* beyond which it is impossible to cool a body. Neither are the zero points on other thermometers; man puts them where it is convenient, but the absolute zero of temperature is not fixed by man, Nature having established it for man to discover.

Experiments on the expansion of gases kept at a constant pressure show that the volumes and temperatures increase and decrease proportionately; the volume increasing $\frac{1}{273}$ for each degree Centigrade increase in temperature and decreasing $\frac{1}{273}$ for each degree Centigrade decrease in temperature.

This being so, we see that, *mathematically*, at a temperature of —273 deg. Cent. or —459.4 deg. Fahr. (the minus sign means negative, means below zero), the volume would disappear. Experiments show that this law, called the Law of Charles, holds true within the limits which we are able to measure. In making calculations in thermodynamics it is sometimes desired to use the absolute zero.

SENSIBLE AND LATENT HEAT.

It is important in boiler practice to know how water is affected by heat. At the temperature of 32 deg. Fahr., water changes from a solid to a liquid or from a liquid to a solid; ice forms or melts; it is a *critical* temperature. To melt one pound of ice at 32 degrees into water at 32 degrees, 144 heat units or B.t.u. must be applied to the ice; and, to freeze one pound at 32 degrees into ice at 32 degrees, 144 B.t.u. must be taken out of the water. To raise the temperature of one pound of water from 32 to 212 degrees, which is the boiling point at atmospheric pressure, 180 B.t.u. must be absorbed, and to cool it from 212 to 32 degrees, 180 B.t.u. must be

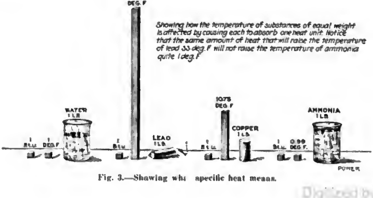

33 DEG. F
Showing how the temperature of substances of equal weight is affected by causing each to absorb one heat unit. Notice that the same amount of heat that will raise the temperature of lead 33 deg. F will not raise the temperature of ammonia quite 1 deg. F
WATER 1 LB
1 B.t.u.
1 DEG F
1 B.t.u.
LEAD 1 LB
10.75 DEG F
COPPER 1 LB
1 B.t.u.
AMMONIA 1 LB
1 B.t.u.
0.99 DEG F.
POWER

Fig. 3.—Showing what specific heat means.

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* Reproduced from *Power*.

given up by the water. To cool one pound of water from 212 to 32 degrees, 180 B.t.u. must be taken from the water. But, to boil one pound at 32 degrees into steam at 212 degrees will require

180 B.t.u. + 970.4 B.t.u. = 1,150.4 B.t.u.

Remember that this is *above 32 deg. Fahr.* and not above the thermometer zero or the absolute zero.

Notice that the steam is no hotter than the water from which it was produced after the water reached 212 degrees, although it took over 5.3 times as much heat to turn it into steam as it did to raise its temperature from 32 degrees to 212 degrees.

The mercury in a thermometer placed in the water while it was being heated from 32 to 212 degrees, or the boiling point, would have risen from 32 to 212 degrees. You could see the water getting hotter; the thermometer would show that it was absorbing heat. But, after 212 degrees had been reached, and, although heat were still applied to the water, a thermometer would not show any increase in temperature even though all the water was boiled into steam, and we know that over five times as much heat was needed to make steam of the water as was necessary to get the water ready to make steam. Neither would a thermometer show that it required any additional heat to melt ice at 32 degrees into water at 32 degrees, or any removal of heat to cool water at 32 degrees into ice at the same temperature.

We have just considered the two kinds of heat known as sensible and latent heat. Sensible heat was that amount of heat applied to the water to raise its temperature from 32 to 212 degrees or the temperature at which steam began to form. It was sensible, i. e., it was apparent to the senses; in this case, the sense of sight when we saw the mercury rise in the thermometer. The relative amounts of these two kinds of heat are shown in Fig. 2.

The heat required to make steam of the water at 212 degrees was not apparent to the senses, except that we could see the steam escape as it was made, but we could not detect the added heat by the aid of a thermometer or by feeling the water. The heat was latent, and that is what is meant when *latent heat of vaporization* is mentioned. It is the heat required to turn a liquid into a gas without change of temperature. To boil into steam a pound of water at 32 degrees, then, requires 180 B.t.u. of sensible heat and 970.4 B.t.u. of latent heat, or a total of 1,150 B.t.u. And this latter amount is what is meant when *total heat* or *total heat of the steam* is spoken of, as in the steam tables. *Latent heat of fusion* is the heat that must be taken from a liquid to make it solidify without change of temperature, as when water at 32 deg. Fahr. freezes into ice.

THE MECHANICAL EQUIVALENT OF HEAT.

If a one-pound weight fell from a shelf 778 feet from the ground, it would strike the ground with 778 foot-pounds of energy. This number of foot-pounds is called the *mechanical equivalent of heat*, because with a perfect apparatus it would take the same amount of energy to raise the weight up to the shelf, as it would to raise the temperature of one pound of water 1 deg. Fahr.

So, when it is desired to express heat energy in terms of mechanical energy, we have

Mechanical energy = heat energy or B.t.u. × 778

and

$$\text{Heat energy or B. t. u.} = \frac{\text{mechanical energy}}{778}$$

If a steam plant could use all the heat in the coal it received, then all of this heat would be converted into work at the engine shaft. Thus, from a pound of coal containing 14,500 heat units per pound, we would get

14,500 × 778 = 11,281,000 foot-pounds

of mechanical energy.

The plant makes use of but very little of all the heat in the coal. The boiler, if handled well, will advantageously use, say, 80 per cent, or

14,500 × 0.80 = 11,600 B.t.u.

Now of this the engine, which we will assume is a good compound condensing one, will turn into work, say, 19 per cent of all the heat it receives, which in this case we assume to be 11,600 B.t.u. for each pound of coal burned in the boiler.

11,600 × 0.19 = 2,204 B.t.u.

For each pound of coal burned containing 14,500 B.t.u. there is available at the engine shaft only 2,204 B.t.u. The amount of heat turned into useful work multiplied by 100 and divided by the heat in the coal gives the percentage of the total available heat in the coal that was turned into work, or

$$\frac{2204 \times 100}{14,500} = 15.2 \text{ per cent.}$$

And this amount is called the *thermal efficiency* of the plant.

SPECIFIC HEAT.

You cannot soak up as much water with a wad of paper as with a sponge of equal volume. Neither will a granite block soak up as much as an ordinary red brick. And so on with various substances; their *capacities* for absorbing liquids are not the same.

The *capacities* of different substances for absorbing heat vary in the same way. If you put one heat unit into a pound of water, which is at, say, 62 deg. Fahr., you raise its temperature one degree, or to 63 deg. Fahr. If you put the same amount of heat into a pound of silver, its temperature will increase 18.1 deg. Fahr., and for lead it would increase the temperature 33 degrees; for copper, 10.75 degrees; for ammonia, 0.90 degree, and so on, each substance having its own peculiar capacity for absorbing heat to produce a given rise in temperature. This is shown in Fig. 3. This capacity is called the *specific heat* of a substance, because that amount will produce a temperature change in a given substance that it will not produce on any other; it is specific for that substance. *Specific heat*, then, is the *heat energy required to raise a unit weight of matter 1 degree as compared with the heat needed to raise a unit weight of water 1 degree.*

In order to compare the heat required to produce an increase of 1 degree in some substance, we use water as a standard, for water is in common use and requires one heat unit to produce an increase of one degree; its specific heat is 1, or unity. As used in engineering calculations, specific heat is a ratio; it expresses the relation that exists between two quantities, as

$$\text{specific heat} = \frac{\text{heat required to raise 1 lb. of matter 1 deg.}}{\text{heat required to raise 1 lb. of water 1 deg.}}$$

APPLICATION OF SPECIFIC HEAT.

In engineering it often is important to know how much heat is required to increase the temperature of a substance one degree, to know its specific heat.

For example, it is desired to know how much heat is carried away by the flue gases per pound of fuel burned. The specific heat of flue gas is generally taken as 0.24; i. e., it takes 0.24 B.t.u. to heat a pound of flue gas one degree. So to find the heat lost in the flue gases, we multiply the weight of gas made by a pound of fuel by the specific heat, or 0.24, and then multiply this product by the difference in temperature between the gases leaving the boiler and the air entering the furnace. The same general method applies for finding the amount of heat absorbed or given up by any substance.

The Calculation of the Condenser Dielectric Constant

By Kenneth Richardson

I wish to make a condenser of a certain capacity for my wireless transmitter or receiver. Someone has kindly directed me to use the following formula:

$$C \text{ in micro-farads} = 0.0000002247 \times \frac{ka}{s}$$

In which *a* is the combined area in square inches of one side of all the sheets of dielectric between plates,

s is the average thickness in inches of the dielectrics between plates, and

k is the dielectric constant.

INDUCTIVE CAPACITY CONSTANTS OF CONDENSER DIELECTRICS.

Air	1.00		
Beeswax	1.80	to	2.00
Glass	3.00	to	10.00
Gutta percha	3.80	to	3.90
Hard rubber	2.21	to	3.15
Mica	4.00	to	8.00
Paraffine wax	1.68	to	2.30
Paraffine oil	1.86	to	1.92
Petroleum	2.04	to	2.42
Pitch	1.75	to	1.80
Resin	2.50	to	2.60
Shellac	2.95	to	3.80
Turpentine	2.15	to	2.43
Vulcanite	2.45	to	2.50

In referring to a table of dielectric constants it is found that *k* is quite an indefinite quantity. For example, the constant of glass varies between 3 and 10, depending upon the quality. The dielectric constant cannot be known by the appearance of the substance. This is an electrical property of the substance and electrical means must be employed in order to arrive at its value.

For a certain capacity, then, say 0.005 M. F., how may I know the size and number of sheets or plates to use, since I do not know the exact dielectric constant of the material?

This is often the problem of those who design their own apparatus. Usually the dimensions are guessed at, resulting in an unbalanced outfit.

The method outlined will enable anyone with a wave meter to accurately calculate the dielectric constant of any insulator very easily.

Connect up the instruments comprising the closed circuit of the wireless transmitter in the usual manner. Adjust the helix for a certain wave, say 200 meters.

Our method of getting the dielectric constant is to make a small condenser of one or two plates of dielectric to be tested, this sample condenser to be substituted for the standard condenser in the closed circuit and the effect upon the wave-length noted on the meter. We can then know the exact capacity of the sample condenser, and from this know the dielectric constant by employing the simple formulas to follow.

It is necessary to get the exact inductance of the closed circuit part of helix which was adjusted for 200 meters wave. The helix inductance is found by the formula:

$$L \text{ in micro-henries} = \frac{101.5 \times N^2 r^2}{l \times 1000}$$

in which *N* is the exact number of turns in circuit,

r is the radius of the helix in inches, and

l is the exact height in inches of the helix (effective turns in circuit only).

Let us assume a helix inductance of 10 M. H.

We now have both the wave-length and inductance of the circuit.

The sample condenser is now made and substituted, care being taken to have voltage of the spark coil on transformer reduced so as not to puncture the sample dielectric.

A very tiny spark is all that is necessary for the test.

Without disturbing adjustment of helix, operate coil and take a new reading on the wave meter. Let us assume the new reading to be 50 meters.

With the known inductance (10 M. H.) and the known wave-length (50 meters), the exact capacity of the sample condenser is found by the formula:

$$C \text{ in micro-farads} = \left\{\frac{W}{1885\sqrt{\times L}}\right\}^2$$

in which *W* is the wave-length in meters, and *L* is the inductance in micro-henries.

From this, our capacity is 0.000068 plus M. F.

When we know the exact capacity of the sample condenser, measurement is taken of the area of dielectric and the average thickness.

From these data, the exact dielectric constant is found by the formula:

$$K = \frac{Cx}{0.0000002247 \times a}$$

in which *C* is the capacity in micro-farads,

x is the average thickness in inches of the dielectric, and

a is the total area in square inches of one side of the dielectrics between plates.

In the formulas it must be kept in mind that:

(*a*) The capacity of a group of individual condensers in multiple is equal to the sum of the individual capacities.

(*b*) The capacity of a group of individual condensers in series is,

$$C = \frac{1}{\frac{1}{C_1} \text{ plus } \frac{1}{C_2} \text{ plus } \frac{1}{C_3} \text{ plus, etc.}}$$

In which C_1, C_2, C_3, etc., are the individual capacities and C is the joint capacity.

(*c*) Long connecting wires to condenser, spark gap, and helix will make the calculations inaccurate. It is advisable to employ all the helix or helices available for the tests.

(*d*) The open circuit should be entirely disconnected during the readings.

(*e*) Intense brush discharge from the edges of a condenser increase the capacity, throwing the calculations off. Avoid extreme high voltage.

The Cost of Building the Panama Canal

The widely published official figures of the cost of the Panama Canal have possibly given the general public an exaggerated idea of the cost of the canal as a piece of engineering work. The statement has been made that the entire cost of the canal to the United States when completed will be in the neighborhood of $400,000,000, and it is a natural conclusion that the bulk of this expenditure has gone into the work of digging the canal and constructing the locks.

It will surprise many engineers even, we doubt not, to learn from figures published in the last number of the "Canal Record," that up to March 31st, 1914, the entire expenditure on the canal in the Department of Construction and Engineering had been only $204,087,000. The total expense up to the same date for all purposes connected with the canal was $322,650,000. The chief items in the account, apart from construction and engineering, were in round numbers, civil administration, $7,000,000; sanitation, $17,000,000; fortifications, $5,000,000, and general items, $90,000,000. Under this latter head are included the payment of $40,000,000 to the French Canal Company and $10,000,000 to the Republic of Panama. There is also included under this head very heavy expenditures for the reconstruction of the Panama Railroad, the construction and repair of buildings and the cleaning up of the cities of Colon and Panama.—*Engineering News.*

Electrical Driving for Rolling Mills—II[*]

Its Adaptation to Existing Steam-Driven Plants

By L. Rothera

Concluded from Scientific American Supplement No. 2022, Page 214, October 3, 1914

Before passing on to the method of applying the drive, it would perhaps be well to make a few remarks with regard to the advisability of using continuous current or 3-phase current as the source of power. This is a question which is fairly often settled by the conditions of supply prevailing in the district, but, if it is a question of generating power in the works themselves, very careful consideration must be given on account of a number of reasons. When looking into this question, the following factors must be considered:

(1) The most suitable type and cost of the central station plant.

(2) The cost of transmitting the power to the various points where it is required.

(3) The most suitable types of motors for the main drives; the most suitable types of motors for the auxiliary drives.

In the case of a works lying closely around the central station, the capital cost involved by installing a 3-phase plant or a continuous-current plant would be approximately the same, but should there be long distances to which considerable amounts of power have to be transmitted, then the extra cost of cable involved in the transmission of direct-current power will be very much in excess of that of a high-tension 3-phase scheme, since in the former case a voltage higher than 550 volts cannot be considered. The cost of the cables is thus very frequently the deciding factor as to whether 3-phase or continuous current shall be employed throughout the works. As against this cost must be set the, perhaps, more satisfactory working of continuous-current machines for driving auxiliaries, such as live rolls, saws or shears, but it must be pointed out that there are very many works equipped to-day with 3-phase motors for these purposes which are giving every satisfaction.

In the case of the main mill drives, the chief question in deciding the type of motor is, as to whether a variable speed is required or not. If a variable speed is required, as in the case of merchant mills, then a continuous-current motor, which can have its speed varied by means of shunt regulation of the field, is the simplest and best proposition for the purpose. If a constant speed only is required, as in the case of a sheet mill, the disadvantages of the 3-phase motor are not so great, although, even in such cases, it is very often a question as to whether the saving in efficiency by putting in the continuous-current motor does not outweigh the greater cheapness of the 3-phase motor. This saving in efficiency is due to a number of causes, which are perhaps of interest.

Take the case of a large sheet mill which requires a motor of, say, 1,000 or 1,500 horse-power, and a speed on the mill of 30 to 32 revolutions per minute. With a mill of this sort, a heavy flywheel of 100 to 150 tons would be necessary, running at the mill speed, in order to equalize the very heavy peak loads attendant on this class of work, and a fall in speed of at least 10 per cent from no-load to full-load would be necessary, so that proper use can be made of the stored energy.

Take now the case of a 3-phase motor. It is almost impossible to build such a machine running at a speed of 32 revolutions per minute, on account of the very large number of poles which would necessarily be entailed, and even if such a machine were built, the power factor would be so bad that very few power companies would permit it to be connected to their mains. It would thus be necessary to put in a higher speed motor with some form of reduction transmission between the motor and the mill.

In the case of a continuous-current motor, there is no difficulty attached to the building of a machine to run at this speed, so that in this case there is—first, a saving in the transmission losses, and secondly, a saving in slip resistance losses. These latter losses occur in the case of the 3-phase motor due to the fact that the only method of reducing the speed of a plain induction motor is by inserting resistances in the rotor circuit, and the loss in these resistances is proportional to the fall in speed. To reduce the speed 10 per cent on full-load, as is necessary to utilize beneficially the flywheel energy, a loss of 10 per cent would occur in the resistances. On some tests which were taken on a sheet mill it was found that the average loss due to the slip resistance losses represented between 13 and 15 per cent of the total energy consumed, and when to this loss is added the transmission loss, which may equal another 5 or 10 per cent, the advisability of installing a direct-coupled continuous-current motor to such a mill must be very carefully weighed.

This question of providing a variable speed on the drive is one which has led to the evolution of a large number of alternative methods of enabling a 3-phase motor to work at a variable speed without the serious loss in efficiency which occurs in the case of an ordinary 3-phase induction motor, which, as mentioned above, can only have its speed varied by the insertion of resistances into the rotor circuit, which method involves a loss of power proportional to the fall in speed, that is, taking the case of a motor running with a normal speed of say 300 revolutions per minute, there will be a loss in power and efficiency of 50 per cent if the speed is reduced to 150 revolutions per minute. The method employed has usually been the addition of an auxiliary piece of apparatus which modifies the existing 3-phase motor and causes it to act more on the lines of a continuous-current shunt-wound motor.

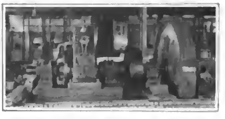
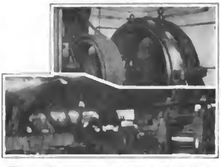


Fig. 13.—Continuous current motor coupled to mill, shown in Fig. 12.



Figs. 14 and 15.—Typical rope drive on large sheet mill. Motive power, 1,060 horse-power. Heavy flywheel, weight of rim 100 tons, diameter 30 feet.

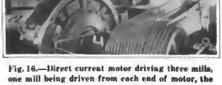


Fig. 16.—Direct current motor driving three mills, one mill being driven from each end of motor, the third by ropes.

The first method that may be mentioned is the addition of a frequency changer, as it is called, which consists of a small machine driven either mechanically from the main motor, or electrically through a separate small motor. This small machine is supplied with power from the slip-rings of the 3-phase motor and transforms this power into the correct pressure and frequency to enable it to be returned to the line. By this means, when the speed of the induction motor is reduced, the power which normally would be lost in slip resistances is returned to the line, thus making a great saving in efficiency.

A second method is to have a 3-phase motor and a small auxiliary continuous current motor coupled together, and an electrical connection between the rotor of the 3-phase motor and the commutator of the continuous current motor taking place by means of a separate small rotary converter. In this case the power which would normally be wasted in slip resistances is transmitted through the rotary converter to the auxiliary continuous current motor, which thus adds its power to the power of the main 3-phase motor.

A third method combines the rotary converter and the auxiliary continuous current motor, mentioned above, into 3-phase commutator motor, thus two machines only are employed instead of three.

Any one of the above methods enables a speed regulation to be obtained in practically as simple a manner as it is obtained in the case of an ordinary shunt wound continuous current machine, and the efficiency throughout the range of speed remains very high.

An alternative method of getting over the difficulty of the fixed speed attendant on the employment of 3-phase power is to provide step-pulleys on the motor, and to drive through ropes on to the mill. By this means a maximum of three or four speeds at most can be given efficiently, and any intermediate value has to be obtained by the insertion of rotor resistances, which, as explained above, is a wasteful method. The method of changing over from one speed to another is also cumbersome, due to the fact that the motor has to be capable of movement both axially and in a direction at right angles thereto in order to allow the same set of ropes to be used. In order to expedite this change-over, there have been cases where small motors have been put down for moving the beds. This type of drive, although somewhat cheaper than the systems mentioned above, has a further disadvantage in that it is not possible to obtain any desired speed between the upper and the lower limit, and experience has shown that in merchant mill work the difference of a few revolutions in the speed of the mill is of very great importance indeed for satisfactory working, and that it is worth while incurring a somewhat extra capital cost to enable this condition to be obtained.

With regard to the method of application of the drive, there are four alternatives which have to be considered:

(1) A direct coupled motor.

(2) A motor driving through gearing.

(3) A motor driving through a belt.

(4) A motor driving through ropes.

Modern practice to a great extent has gone in favor of the direct coupled drive, even for speeds as low as those required for a heavy sheet mill, namely 32 revolutions per minute. Of course, in the case of merchant mills where the speeds may vary from 100 revolutions per minute upward, the direct-coupled drive presents no difficulties, and the question of the difference in capital cost between a direct-coupled drive and a gear or rope drive has not to be so seriously considered as is the case in a very slow speed drive. In a great many cases, however, the extra additional cost of the slow speed drive is more than counterbalanced by the gain in efficiency due to the absence of any form of transmission losses between the motor and the mill. These losses are a heavy item in the yearly expenditure, as can be seen when the losses in the various forms of transmission are considered. Taking the case of gearing, it can be assumed with a fair degree of accuracy that the losses taking place in a single reduction represent about 5 per cent *of the power which is being transmitted.* This value is perhaps excessive when taken on a gearing which has just been newly put down, but for varied conditions of working, and when the gears have become somewhat worn, it is not safe to assume that any less loss than this takes place. In the case of a rope drive the percentage loss taking place in the drive alone is a somewhat moot point, some authorities giving the losses up to as much as 10 per cent, while others place the figure as low as 2 per cent. As, however, one of the first authorities on rope drives suggests that a figure of 5 per cent is a good working figure, it is probably quite safe to accept this figure as being the correct amount to take into account. Special emphasis in the case of a rope drive must be laid upon the fact that the loss occurring in the ropes remains practically constant whether the ropes are running light or transmitting power, and the loss can be taken *on the normal power which the ropes are designed to transmit.* In this respect, therefore, the rope drive is not as efficient as a gear drive, although it certainly provides a very nice flexible medium between the motor and the mill. Another drawback in the case of a rope drive is the amount of space taken up, and the cost of upkeep of the ropes, which is very considerable, the life of the ropes being a very variable figure, ranging from about two years to perhaps five or more.

With regard to a belt drive, this form of transmission has not been very extensively employed in this country for this class of work, but it has been used to a somewhat greater extent on the Continent, and has been employed for powers up to 1,800 horse-power normal and 3,000 horse-power maximum with, it is believed, very satisfactory results.

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[*] Paper read before the Institution of Mechanical Engineers.

In order to show in a simple form the losses which may occur throughout the year due to transmission losses, a case is taken of a sheet mill with a normal power of 600 horse-power on the motor, and an average power taken by the mill of 200 horse-power. Assuming that the mill is working for 110 hours per week, and 50 weeks to the year, the losses in the case of a gear drive would be 5 per cent of 200 horse-power, namely 10 horse-power for 5,500 hours, while in the case of a rope drive the losses would be 5 per cent of 600 horse-power, namely 30 horse-power for the same number of hours. Taking the cost of power at 1 cent per unit, the loss in these two methods of drive as compared with the direct-coupled drive would be roughly $500 in the case of the gear drive, and $1,500 in the case of the rope drive, representing with a 10 per cent interest on the capital outlay $5,000 and $15,000 respectively of extra plant.

Where the question of converting an existing mill has to be considered, the method of drive adopted must be dependent, to a very large extent, on the lay-out of the works, as there may be other mills, roof columns, or other reasons, which may render any one of the drives mentioned above impracticable.

One of the first questions which arises when the conversion of an existing mill is contemplated is the length of time for which the mill will have to be shut down in order to make the change-over, and it is imperative, in most cases, that this time should be reduced to a minimum. This consideration is one which, in a number of cases, lends itself to the introduction of a rope drive, as the foundations of the motor and the motor itself can be put down without interfering with the working of the mill, and the mounting of the rope pulley for coupling to the mill is very often a matter of quite a short time, and sometimes not much more than a long week-end. In the case of a direct-coupled drive, a method of avoiding stoppage is shown by the photograph, Fig. 12, where a long intermediate spindle is introduced between the pinions and the motor, this spindle spanning the space taken up by the existing engine. The change-over in this case from the steam to the electric drive did not involve any stoppage of the mill. Fig. 13 shows the continuous-current motor coupled to this mill.

It is sometimes possible to put down the motor on the side remote from the steam-engine, and this was done on the second electrically-driven reversing mill which was installed. This plant has been working now for 5½ years, and no trouble whatever has been experienced through its having been found necessary to transmit the drive through the bottom spindle to the pinions—a view of the plant is shown in Fig. 3 (page 213). It may be said that when this plant was first put down the engine was retained in place so that it could be re-coupled to the mill in the event of anything going wrong with the electrical drive, but it has never been used since the electrical plant has been set to work. In some cases it is possible, by the introduction of another gear wheel, to put the motor in position without shutting down the plant, and in Fig. 7 is shown a 250 horse-power motor driving through gearing on to a sheet mill where this procedure was adopted.

When applying a motor drive to a mill, an important consideration is the weight of flywheel to be adopted, and this is a matter which can only be satisfactorily decided through experience. It is not a safe method to assume that the flywheel, as fitted to the existing engine, will be satisfactory in the case of a motor drive, since, when an engine is overloaded, it will slow down until finally it will stall. A motor, of course, does not act in the same way, but has a pre-determined drop in speed from no-load up to the maximum load which it can safely stand, and if this maximum load is exceeded, the circuit breaker or switch protecting the motor will operate, shutting down the plant. In the former case, that is, of the engine, the whole of the stored energy in the flywheel is available to pull the metal through the rolls in conjunction with the engine, while in the latter case, assuming a 20 per cent fall in speed between no-load and 100 per cent overload, only 36 per cent of the stored energy is available, after which the motor ceases to drive, leaving only the flywheel stored energy. This is, to some extent, counteracted by the fact that the permissible overload on the motor will be 100 per cent in excess of the normal power, while in the case of an engine the overload will not be much more than 25 per cent, but it can generally be stated that the flywheel will require to be heavier in the case of the motor drive than in the case of the engine. The heavier the wheel, of course, the steadier the power demanded from the motor, but here again the question of cost is the deciding factor, and a fluctuating load will not prove harmful to a motor provided that the maximum peaks are not excessive. This is clearly shown by the success of the motors employed for reversing mill work—where they are coupled direct to the pinions and take the full power demanded by the mill.

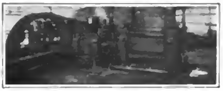
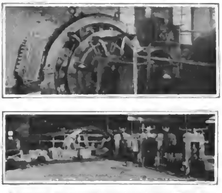


Fig. 17.—The rope-driven mill and one of the direct-coupled mills.



Figs. 18 and 19.—Variable speed motor, 600 brake horse-power. Speed, 300-450 revolutions per minute, driving rail mill.

Another question which arises if there is some form of transmission between the motor and the mill is, as to whether the flywheel be placed on the high-speed motor shaft, or be direct coupled to the slower speed mill. Modern practice in this respect has usually decided in favor of the flywheel connected to the mill, and this would appear to be the correct solution of the matter, as, in this position, the flywheel absorbs the peak loads of the mill before they come back on to the transmitting mechanism.

The cost of having a large slow speed flywheel is usually somewhat in excess of having a high speed smaller flywheel, but the difference is not, in many cases, very great on account of the fact that the full peak loads of the mill in the latter case have to be transmitted from the motor and flywheel through the gearing or ropes as the case may be. The size of the gearing, and the number of ropes, will have to be very materially increased to withstand this extra strain. As the ropes and gearing are usually admitted to be evils, the reduction of them to their smallest dimensions is advisable, and this can be done by designing them to transmit only the normal power of the motor and allowing excessive mill peaks to be taken up by the flywheel directly coupled to it.

A form of drive which has been suggested and employed in one or two cases is to mount the flywheel on the motor shaft, and to drive through a worm reduction gear on to the mill. This is a very interesting new departure, and time will show whether it possesses advantages over the better known drives. It would appear to be a very satisfactory method if a steady power is demanded, such as, for instance, a wire mill or cold roll drive in a tinplate mill where there are no heavy peak loads to be taken up by the flywheel, but where the full power of the motor and flywheel has to be transmitted through such a gear it is to be seen whether it can be made of sufficiently strong design to give an efficient working life commensurate to the initial cost of the plant.

The various types of drives mentioned above have been mostly shown by the preceding illustrations, and Figs. 14 and 15 show a typical rope drive on to a large sheet mill, the motor power being 1,000 horse-power with peak loads up to double this amount. The heavy flywheel necessary for this type of drive is shown very clearly in Fig. 15, the weight embodied in the rim being approximately 100 tons with a diameter of 30 feet.

Figs. 16 and 17 show a rather interesting drive which has been installed in an iron works where a motor has been put down for driving three mills, all of which require practically a 2 to 1 speed variation for dealing with the various classes of work. A direct-current motor is employed for the drive as shown in Fig. 16, one mill being driven from each end of the motor and the third by means of ropes. Fig. 17 shows the rope-driven mill and one of the direct-coupled mills.

Figs. 18 and 19 show a rail mill driven by means of ropes from a variable speed motor of 600 brake horse-power, the speed of the motor being variable between 300 and 450 revolutions per minute. In both the cases mentioned above, flywheels are fitted to the mills to equalize the loads which the motors have to take.

Utilization of the Waste Heat of Slag

Much has been done in the last few decades to utilize the heat in iron blast-furnace slags, the annual production of which amounts to close on 200,000,000 tons. If their temperature is taken at 1,500 deg. Cent., the quantity of heat they contain must be enormous, all of which is wasted.

Efforts were made some years ago by the late Sir Lowthian Bell to save this heat, but the state of engineering achievement in his time did not permit a satisfactory solution of the problem. Further experiments have been in progress at the Clarence works of Messrs. Bell Brothers, Middlesbrough, for some years, the patents being in the hands of the Slag Power Company. The first plan was to drop the molten slag as it comes from the blast furnaces into water, and use the steam thus produced in a low-pressure turbine. But the considerable quantities of hydrogen and sulphureted hydrogen produced along with the steam gave rise to difficulties in connection with obtaining the high vacuum necessary to the efficient working of the turbine. These difficulties were overcome, but a quantity of fine sulphur was also produced, and this it was found impossible to eliminate from the steam. Yet if it had not been removed it would have damaged the blades of the turbine with which it came into contact, and would also have blocked the steam passages. Another difficulty was caused by the fact that the hot blast-furnace slag when thrown into water froths up into a foam-like substance, which floats, and means had to be devised for submerging and removing it.

Instead of attempting to use directly in the turbine the dirty steam generated by the contact of the slag with the water, the plan finally adopted was to employ it indirectly for generating clean steam by means of a heat exchanger, the particular form adopted being a Kestner single-effect climbing film evaporator. The hot slag is run direct from the blast furnace into the primary generator, in which an upright shaft with four blades revolves, keeping the water in constant rotation. When the slag drops through the orifice the velocity of its fall carries it well below the lip, and before it rises to the surface it is swept by the moving water past the orifice and inside the seal. An elevator then lifts it from the generator and drops it through a second seal; by this time it is waterlogged and sinks, and it is then collected by a second elevator, which drops it into railway trucks for removal. The dirty steam passes from the generator to the evaporator, where it is used to produce clean steam, which is employed in the turbine. In the case of copper slag, the second elevator is not required, since the slag does not float in water, but immediately sinks.

Over 740 kilogrammes of water have been evaporated per 1,000 kilogrammes of blast-furnace slag containing 550,000 calories; deducting 18,000 calories removed with the slag at 100 deg. Cent. and 42,000 removed with the water taken up by the slag (on the assumption that it absorbs 50 per cent of water), the available heat is 490,000 calories, or, if an allowance of 25 per cent is made for loss, 367,500 calories, which divided by 622 give 590 kilogrammes of steam. As the result of many experiments, the average efficiency of the evaporator is found to be 91 per cent, but taking it at only 80 per cent the amount of clean steam available for the turbine is 472 kilogrammes, and this with a consumption of 13 kilogrammes of steam per horse-power, which is an excess of that guaranteed by the makers of the turbine with a vacuum of 28.5 inches and a vacuum of 7 inches over the water in the evaporator, means a yield of over 36 horse-power per 1,000 kilogrammes of slag.

Copper slag contains less heat than blast-furnace slag, the amount being found by experiment to be from 318 to 350 calories per kilogramme, and therefore by a similar calculation 1,000 kilogrammes will produce 291 kilogrammes of clean steam, equivalent to a yield of, say 21 horse-power in the turbine.

It is estimated that with a 1,000-kilowatt plant with 75 per cent load, the cost of generating 1 kilowatt would be 0.32d., whereas with a high-pressure steam plant using coal at 14s. 6d. a ton it would be 0.48d., the economy realised by the aid of the heat from the slag being thus 0.16d. per kilowatt, which under the conditions stated would amount to £4,300 a year. It is stated that the upkeep of the generator and evaporator is small. As the slag goes directly into the water, only steam at 100 deg. Cent. comes in contact with the plant, which is thus not subjected to any great differences of temperature, while experience indicates that there is no action from the gases on the plates or tubes of the evaporator, provided they are kept clean.—*Engineering and Mining Journal.*

Stress Distribution in Materials*

A Review of Various Methods Suggested for the Solution of Important Engineering Problems

By Prof. E. G. Coker, M.A., D.Sc., M.Inst.C.E.

THE subject of stress distribution in materials, which I have chosen for this address, is not one which an engineer can claim as his peculiar province, for it has been and still is a fruitful field of investigation for the mathematician, the physicist and the geologist, and has always been so since the commencement of scientific inquiry.

The development of architecture from the earliest dwellings of savage races to the great temples of Egypt and Greece, the bridges and aqueducts of the Romans, and the mediæval buildings of Europe, all bear witness to the accumulation of practical knowledge of the properties of materials and of the stress distribution in structures, which we cannot fail to admire, although we know far too little of the way in which these ancient structures were planned and constructed. The magnificent arched and domed buildings of the Roman period, and the stately cathedrals of later times with their wealth of architectural form—tower and spire, flying buttress and vaulting—all show how considerable was the practical knowledge of stress distribution possessed by the master builders who planned and carried out these great structures. We, who inherit these buildings as a precious legacy of bygone ages, have at our command far greater resources in the accumulated knowledge of centuries of scientific discovery and invention, and can build more complex structures—great bridges of steel, towering frameworks covered by a thin veneer of masonry, and floating arsenals of the most bewildering intricacy. All these we can show to our credit as the result of the steady increase of scientific knowledge applied to practical ends, but, even now, knowledge of the stresses which come upon these complex structures and machines is relatively small. Scientific investigations of engineering problems of stress still lag behind constructive ability, and defective knowledge is obscured more or less by approximate theories and buttressed by factors of safety, which serve in one instance perhaps, but show in others that they have merely given a sense of fancied security with no real basis, and are more properly factors of ignorance, to be discarded at the earliest moment. Who, for example, can say with certainty what is the stress distribution throughout the compression members of a great bridge, built up of complicated steel shapes and plates, united by stiffening angles, gusset plates, and innumerable rivets? There is probably good reason for the belief that a great strut is relatively weaker than a small one, when both are designed according to the same approximate formulæ now used in current practice, and engineers are unwilling to take the responsibility for such members in a great structure, without providing a very ample margin of safety to cover the contingencies arising from lack of precise knowledge of the strength of these members. So numerous are the problems which arise in the design and construction of machines and structures, that it is perhaps not unprofitable to devote a short hour to the consideration of some of the available means which an engineer can use as a guide for his applications of science to construction, since of whatever kind are the professional activities he pursues, his place in the scheme of affairs mainly depends on his ability to make machines and structures for directing and modifying natural sources of power in known ways, or applying them to new purposes as scientific discoveries advance the boundaries of knowledge.

It is of some help to our appreciation of the achievements of the great constructors of past ages, if we remember that they probably all held the erroneous view that materials of construction are perfectly rigid bodies, and, indeed, we know that as late as 1638 Galileo Galilei was of that opinion, and that he came to an entirely wrong conclusion as regards the stress distribution in a loaded cantilever.

From the standpoint of the engineer, nothing is of more practical importance than the great discoveries of Hooke and Young, that bodies like metal, wood, and stone are "springy" and have a simple linear relation between stress and strain. It is probably within the mark to say that nine tenths of all the experimental investigations on stress distributions in structures have been entirely based on the fundamental principles which they enunciated, and new uses are continually arising. The recent application of the steam turbine to the propulsion of ships produced a profound change in marine-engine practice, and incidentally involved an entire reconstruction of methods for obtaining the horse-power developed, which had been gradually perfected from the time of Watt, but were absolutely useless for the new system of propulsion. Hooke's discovery of the essential springiness of metals enabled engineers quickly to devise new instruments capable of accurately measuring the infinitesimal angular distortions of propeller shafts, and from these to determine the horse-power transmitted by the aid of an appropriate modulus.

The construction of tall buildings affords another example where advantage has been taken to determine the loads upon columns by measuring the minute diminutions of length as the structure proceeds, thereby affording a valuable check upon the calculations for these members, and a reliable indication of the pressures supported by the foundations.

The distribution of stress in buildings constructed of composite materials like concrete reinforced with steel has also been examined by similar methods, and much data for guidance in future constructional work has been obtained, especially in the United States of America.

The still more difficult problems involved in the determination of the stresses in joints and fastenings of complicated structures have often been investigated by purely mechanical measurements of strain, and the experimental investigations of Professors Barraclough and Gibson and their pupils upon the distribution of stress due to riveted joints and curved plates of boiler shells afford a notable example of the successful application of the measurement of small strains to a stress problem of great complexity.

That "science is measurement" is here sufficiently obvious, and it seems only due to the memory of that great engineer, Sir. Joseph Whitworth, to refer to his great mechanical achievements of a true plane and well-nigh perfect screw, which enabled him to measure changes of one millionth of an inch, and thereby gave experimental investigations of strains a new impetus, which is reflected in subsequent work on the subject. Nor must we forget the no less important exposition, by Kelvin and Tait, of the scientific principles of instrument construction which have done so much for the design of instruments for the precise measurement of strains.

Mechanical measurements cannot, however, completely satisfy all our modern requirements, since they are essentially average values, and fail to accommodate themselves to many of the problems which press for solution.

In the quest for exact experimental knowledge, the measurement of stress at a point becomes of paramount importance, and we may, therefore, inquire what further means the researches of pure science have placed at our disposal for the determination of stress distribution in materials.

It is well known that many materials when tested to destruction show a considerable rise of temperature at the place of fracture, especially in very ductile materials; but Weber was the first to discover that a metal wire when stretched within the elastic limit is cooled by the action of the load, and this result was deducted later from the laws of thermo-elastic behavior of materials by Lord Kelvin, who showed that tension and compression loads produce opposite effects, and that materials which have the property of contracting with rise of temperature show thermal effects of the reverse kind. Although the changes of temperature produced by stress are small within the elastic range—less than 1 deg. Cent. for most materials—yet their effect upon a thermo-couple is readily measurable if the equilibrating effects of surrounding bodies are neutralized or allowed for, so that stress distribution can be determined by thermal measurements at a point. The correction for such disturbing causes is usually an important factor, and is generally so large that experimental work is more suitable for the laboratory than the workshop; but if all necessary precautions are taken a linear relation of stress to strain can be shown to hold up to the elastic limit of the material, while above this point the break-down of the structure causes a rise of temperature of so marked a character that it has been utilized by several investigators as an indication of the yield point.

Experiments, upon members subjected to tension, compression, and bending, show that thermal phenomena afford trustworthy indications of the stress in materials so diverse as a rolled-steel section, a block of cement, and beams of stone and slate. Although no attempt appears to have been made to investigate stress distributions of any great complexity, it seems not unlikely that thermal methods of investigation will ultimately prove of considerable value.

The transparency of metals to Röntgen rays is another phenomenon which has often been suggested as likely to be of service for work on stress distribution in materials, and Mr. Howgrave Graham and I have examined a number of rolled metals under stress up to the breaking point, without, however, discovering any change in the appearance of the material as seen on a fluorescent screen. Although our experiments showed no perceptible change, it is, of course, not impossible that an effect may have escaped our notice.

Another and still more fascinating field of research on stress distribution is afforded by the doubly refractive properties of transparent bodies under stress, a discovery made by Sir David Brewster almost exactly one hundred years ago, and but rarely made use of since by engineers, although Brewster himself immediately saw its value for experimental purposes, and suggested that models of arches might be made of glass, and the effects of stresses due to loading rendered visible in polarized light.

Brewster carried his investigations further, by the invention of a "chromatic teinometer" for investigating the nature of strains, and consisting of plates or bars of glass subjected to flexure in definite ways for comparison with the body under stress.

At a much later date (1841), Neumann developed an elaborate theory for the analysis of strain in transparent bodies due to load, unequal temperature, and set, while still later the youthful genius of Clerk-Maxwell supplied an algebraic solution for the stress distribution in any plate subjected to stresses in its own plane.

The application of optical investigation to the determination of stress distribution in engineering structures and machines has, however, been hindered by causes which, although apparently insignificant, have been very real obstacles, and among these was the absence of a transparent material which could be fashioned into shapes suitable for investigating technical problems. It is not an easy matter, for example, to construct a glass model of a bridge free from internal stress, in the manner suggested by Brewster; and, moreover, glass is extremely fragile under load, especially in cases where the stress distribution in it varies very much, while the cost of construction is very great. Happily there is now no necessity to employ glass for experimental investigation on engineering problems, since modern chemistry has supplied artificial bodies, such as the nitro-cellulose compounds which have optical properties very little inferior to glass, are able to bear great stresses without injury, and also are capable of being fashioned with the ease and certainty of a wooden model. Photographic processes are also able to reproduce the brilliant color effects caused by stress in transparent materials, so that permanent records can now be made for future reference.

The construction of polariscopes for examining models on a large scale is very essential for technical research, and the great scarcity of Iceland spar of sufficient purity and size for use as Nicol's prisms has caused much attention to be paid to the construction of apparatus for producing plane polarized light by the aid of sheets of glass. Fortunately this presents little difficulty, and although the light is not nearly so well polarized as that obtained from a Nicol's prism it is sufficiently so for the purpose. Large quarter-wave plates of mica have also been constructed by my colleague, Prof. Silvanus Thompson, F.R.S., for obtaining circularly polarized light, and these have proved sufficiently exact and exceedingly useful for large models.

It is of importance to show that the stress distribution revealed by a polarized beam of light passing through an elastic transparent material in no ways differs from that obtained by other means, and evidence is available in modern researches, especially by Filon, that the experimental results obtained with glass agree with those of the theory of elasticity, while a satisfactory agreement of a similar kind has also been obtained with nitro-cellulose compounds, although not in so complete and direct a manner. Such an agreement may be expected on theoretical grounds, since the values of the elastic constants do not affect the fundamental equations for stresses in a plane, and although for three-dimensional stress the effect of the stretch-squeeze ratio causes some difference, yet this is usually negligible.

Most of the physical constants of glass have been determined with very considerable accuracy, but other transparent substances have so far received little attention, and their optical constants are not well known. The stress-strain relations of glass and nitro-cellulose have been determined with considerable accuracy, and a useful idea of their relation to metals may be gained from the values of the stretch-modulus, E, and the stretch-squeeze ratio, σ.

The accompanying table shows some average values for a few important materials, and it is of interest to note that the stretch-squeeze ratios of cast iron and plate-glass are very similar, while the values of the stretch modulus are nearly as three to two. These two materials also possess other like characteristics: they are both very brittle, and possess well-developed crystalline structure, so that we may expect the properties of cast iron under stress to be very faithfully followed by plate-glass.

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* An address to the Engineering Section of the British Association for the Advancement of Science by Prof. E. G. Coker, M.A., D.Sc., M.Inst.C.E., President of the Section.

Material.	E	σ
Steel	30,000,000	0.25
Wrought iron	29,000,000	0.28
Cast iron	15,000,000	0.25
Plate-glass	10,500,000	0.23
Nitro-cellulose	200,000 to 300,000	0.40

The high values of the stretch modulus for steel and wrought iron are not, apparently, approached by any transparent material having similar ductile properties, but although nitro-cellulose has a stretch modulus of rather less than one hundredth that of steel, its stress-strain properties are not unlike. In some recent experiments with a miniature testing machine fitted with an arrangement for recording the stress-strain relations of xylonite throughout the whole range of stress up to fracture, the main characteristics of steel appear on a very much reduced scale, and give additional confidence that the results of optical experiments on this material are applicable to metal structures.

The complete analysis of stress distribution in a plate is not, however, a simple matter, and the analysis of Clerk-Maxwell was intended to provide a solution based on the properties of the isochromatic and isoclinic lines, coupled with the law that the optical effect is proportional to the difference of the principal stresses at a point, and to the thickness of the plate.

A principal stress perpendicular to the bounding planes is assumed to have no optical effect; but since many cases have arisen where there are three principal stress components, it seemed desirable to examine such a case experimentally.

Some observations on circular plates clamped at the edges and uniformly loaded over one face, showed that the bending stresses produced in the plate caused very little optical effect, since the tension and compression stresses neutralized one another, while the shear effects also appeared to be practically negligible. The only remaining stresses of importance were those caused by the clamping plates at the boundary, which produced radial and circumferential stresses having circular symmetry, and as the optical effects of these latter disappeared at a small distance from the edge, a field of view was obtained in which the optical effects of load applied perpendicularly to the plate were quite small, even when the internal stresses were very great.

Two circular plates clamped together to enclose a space between them may therefore be used as windows for observing the effect of a uniform pressure upon a transparent specimen, which latter may be a plate with its faces parallel to the end plates closing the chamber. If cubical compression is applied by a fluid, the principal stresses in the plane of the plate produce opposing optical effects, and any remaining effect is due to perpendicular pressures on the faces. The arrangement of experimental apparatus, therefore, took the form of a pair of transparent windows separated by an annular disk, and firmly clamped together by collars. The central chamber so formed was subjected to pressure of air, or other fluid, up to about one thousand pounds per square inch, and afterward the specimen was introduced and the same pressure applied; but no visible change of effect could be observed. Finally, the specimen was set in the field of view outside the chamber, and pressure again applied by the fluid, but still no change was apparent. In all three cases the optical effects produced were small, and practically alike, so that the experimental evidence appears to warrant the conclusion that a principal stress in the direction of an incident beam of polarized light has no optical effect in a thin plate, or at any rate is so small that it may be neglected.

That the retardation between the ordinary and extraordinary rays is proportional to the stress difference perpendicular to the incident beam within the elastic limit of the material may, therefore, be taken as reasonably accurate, although future research may show that it is only an approximation, or even that it is more accurate to commence from a fundamental strain equation; but according to present knowledge there appears to be no warrant for such a procedure.

A more pressing difficulty arises with regard to the optical constant connecting the wave-length retardation with the stress difference. The recent researches of Filon on glass show that the value of this constant is curiously dependent on the previous history of the material, especially as regards its heat treatment. Until further knowledge is gained on this matter it appears to be necessary to guard against errors in stress measurement from this cause by a careful selection and treatment of the material used, since for other artificial bodies we may find that the variation in the constant is not less in magnitude, and is at least as complex as in glass. In some instances the stress optical coefficient may be dispensed with, and Filon has shown, in cases where a theory of stress distribution has been worked out and it is desired to compare it with the results of optical measurements, that the isoclinic lines offer many advantages, since they are independent of photo-elastic constants, and the material need only be subjected to small stresses.

The experimental analysis of stress distribution in a body depends on the possibility of finding the magnitudes and directions of the principal stresses at every point, and in practice it is found the simplest plan to determine the directions of stress from the lines of equal inclination obtained in plane polarized light, and to measure the stress difference by comparison with a wave-length standard, such as a Babinet compensator, or by comparison with a simple tension member set along one of the lines of principal stress, and loaded until the total effect produced is a dark field denoting a zero value. The difference of the principal stresses is then measured in terms of a simple tension. This alone is insufficient to determine the distribution, unless one of the principal stresses is zero, and, in general another independent measure must be obtained. This is very conveniently supplied by the change in the lateral dimensions of the plate under stress, since this change may be taken, in the absence of a third principal stress, as proportional to the generalized sum of the principal stresses throughout the thickness.

The determination of the lateral strains in a comparatively thin plate, forming part of a model of a machine or structure, necessitates measurements of extremely minute linear quantities. If, for example, a plate of xylonite is taken, of the maximum thickness obtainable for optical work, a simple calculation shows that these strains must be measured to an accuracy of one or two millionths of an inch. Several instruments have been designed and constructed for this purpose, to fulfil conditions which appear to be essential for successful use. It is necessary to avoid all chance of injury to the surface of a transparent material, so that the measuring points of an instrument can only be pressed lightly against the surface, and the weight must, therefore, be supported independently of the model. In instruments so far constructed, the measuring mechanism is carried on a U-shaped frame, for convenience of movement from point to point of the specimen. One measuring needle is secured and operated by a calibrating screw, and the other is free to move a multiplying lever system, and thereby tilt a mirror to give an angular deflection, which latter is calibrated by reference to the standard screw when the instrument has been finally secured in place. In recent work the labor of accurately setting the instrument in a number of different positions has proved so great, that my assistant, Mr. F. H. Withycombe, has designed a useful adjunct in the form of a mechanical slide-rest, to effect the required changes easily and expeditiously. In one arrangement, a bracket carries the measuring instrument on a three-point support, and movement is effected by slides arranged to give displacements along three axes at right angles, and their amounts are measured by micrometer screws to an accuracy of rather less than one thousandth of an inch.

These methods of stress determination avoid the difficulties of the Clerk-Maxwell analysis, which necessitates the determination of the equations to both families of isochromatic and isoclinic bands, usually a mathematical problem of considerable complexity. In some simple cases, Mr. Scoble and I have verified the accuracy of the method of lateral measurements for determining the sum of the principal stresses, by comparing the calculated stresses with the experimental values obtained in a plate of transparent material. We have lately carried these experiments a stage further, and have shown that the measured sums of the principal stresses in steel agree with the calculated values. This experimental solution, in fact, gives the stress at a point in a plate, if the conditions are those assumed by the mathematical case of a plate where generalized equations of stress apply.

It is at once obvious, if the utility of experiments on models of this kind is admitted, that experimental evidence is available on a variety of practical engineering problems covering a very wide field of practice, not merely qualitative, but quantitative, and approximating to the needs of the physicist and mathematician, and well within the known variations of the materials with which the engineer has to deal in his daily practice.

During the last few years much attention has been paid to the determination of the stresses in structural elements of primary importance, but only a small number of cases have been examined, since even the simplest problems have proved somewhat difficult, and much time and labor have been spent in perfecting optical and mechanical appliances to suit the special conditions required for investigations on transparent models. A simple example of a case easily examined and of practical importance is that of a tension member subjected to an eccentric load. The optical effects here show a linear distribution of stress due to the combination of direct pull and bending, while the neutral axis moves toward the tension side as the stress increases. Not only can these effects be measured, but if the specimen begins to fail some indication is obtained of the way in which the stress distribution is changed to meet the new conditions, and there is found a tendency to an equalization of the maximum stress at the boundary, although at present the form of the curve of distribution beyond the elastic limit is largely conjectural.

A case like that of a very short member subjected to direct compression is also not without interest, partly because it reveals unexpected difficulties. In the first place it is not easy to apply a pure compression stress, and if the surfaces in contact are not of the same materials it appears to be practically impossible, since the lateral changes are unlike, and shear stress is therefore produced at the plane of the surfaces in contact. In a short member this shear has a very important influence, and by interposing a thin layer of a material, such as india-rubber, between the pressure plates and the short transparent-block, the artificial shear effect produced by the india-rubber is easily shown to influence the distribution throughout, and to increase the stress in a very marked way. Experiments on transparent materials show that the increase of stress may be twenty per cent or even more. Such an effect is known to take place when cubes of stone are crushed between lead plates, and optical investigations on models have enabled a quantitative measure of the effect to be ascertained in this and other cases, thereby confirming the theoretical investigations of Filon on the distribution of stress in such members under various practical systems of loading.

The local effects produced near the points of application of a load are usually of considerable importance, and their influence on the stress distribution in beams has been examined by Carus-Wilson.

The stress effects produced by discontinuities in materials are also of considerable interest, and the cases arising from the necessities of construction are infinite in their variety.

The practical importance of an accurate knowledge of the change in stress distribution produced by changes of section in a member is so thoroughly appreciated that it needs no insistence, and it has received much attention from a mathematical point of view. Thus the local effect of a spherical cavity in a member subjected to uniform tension or compression load has been shown by Love to double the intensity very nearly, while Kirsch has shown that a small cylindrical hole in a tension member trebles the stress intensity. If the hole is elliptical the increase of stress may be still greater, and Inglis has shown, among other interesting cases, that if the minor axis of the ellipse is parallel to the direction of the applied load in a tension member, the stress intensity is increased by an amount measured by twice the ratio of the axis of the ellipse.

A crack, considered as the limiting case of an elliptical hole, is thus seen to give extremely great stresses at the ends, tending toward infinite values for an extremely fine crack.

Optical experiments afford an independent means of examining the alterations of stress intensity produced by discontinuities, and the results are found to agree remarkably well with those obtained from the theory of elasticity. The stress at the boundary of a small cylindrical hole in a plate has been found to be almost exactly three times the stress in the full plate, and the effects of holes comparable with the width of the tension member have also been examined in some detail.

In the case of a rivet just filling the hole and exerting no tangential effect at the boundary, there is a lessened tension stress across the minimum section at the boundary hole, accompanied by a marked radial tension. These effects have been recently confirmed in a mathematical discussion by Suyehiro. Other cases give satisfactory agreement with calculation, and we may therefore feel some confidence that experimental investigation will prove useful in some of the very complicated cases arising out of engineering practice where analysis is difficult, if not impossible.

The effects of overstress in materials may also be examined by optical means, and although the laws relating to stress distribution in overstressed transparent material are not known, the general effects observed in simple cases are fairly evident. If, for example, a tension member of glass is stressed, there is no ductile yielding of the material, and the stress will therefore rise very rapidly at the boundary of a small hole, and fracture will therefore occur with a moderate load. If, however, a ductile transparent material is employed, and the material shows signs of failure at the hole, the breakdown of the structure spreads outward as the load is increased, until we may have a condition in which, within the elastic limit, the curve of stress intensity at the minimum section accords with calculation, but at the overstressed part the stress tends to equalize, and the curve of intensity tends to become horizontal near the hole. The mean value of this part of the stress distribution may be inferred from the difference between the total load and the measured values below the region of failure; but the true distribution of the overstress has not been accurately determined, so that the shape of this peak is largely conjectural.

The effects of groups of rivets such as occur in bridges, boilers, and structural members of all kinds, afford ample scope for further inquiry; but before more exact knowledge can be gained of the condition of stress in a complicated riveted joint it appears necessary to examine thoroughly the very simple cases.

Other interesting cases of discontinuity in structure are afforded by the engine hatchways, gun-turrets, funnel openings, and the like, in ships' decks, and some progress in this direction has been made by experiments on model decks, subjected to loads like those produced when a vessel meets the waves due to a head sea.

Even if the utility of transparent models is left out of account, it is generally acknowledged that many engineering problems are often simplified by the use of models of machines and structures on a small scale, where circumstances forbid experimental examination of the actual work. No defense of their use is, I think, necessary, since the employment of models is a characteristic feature of British methods, not limited to engineers. Kelvin did not disdain their use, and his successors, who have done so much to advance knowledge of the ether and the atomic dust, have freely employed their great ingenuity in the construction of mechanical models and diagrams to explain their views, as in the Lodge cog-wheel diagrams of the ether, the planetary systems of atoms of J. J. Thomson and Rutherford, and the grouping of elements by Soddy.

Engineers have not the same great difficulties which confront those who are advancing the boundaries of pure science; their models are very much what they please to make them; but, even then, problems arise which are sufficiently difficult to tax all the resources of applied science. The behavior of models considered as similar structures is, therefore, a subject which engineers are bound to investigate in order to determine the effects of fixed and moving loads, the action of wind, the pressure and frictional effects of steam and other fluids, and many other problems.

In the majority of cases the simplest and the most direct method is the experimental study of a model, from which to obtain the data required for calculating effects on a full-sized structure, and hence the laws of similarity have received a very close scrutiny.

Although most valuable information can be obtained from models, their usefulness is clearly limited. The effects of the dead weight of a structure are proportional to the cube of the linear dimensions, and are, therefore, not usually measurable on a model except in exceptional circumstances, as, for instance, where elastic jellies are employed, as in the well-known investigations of Pearson on the stress distribution in reservoir dams. Nor are questions of stability easy to solve, since the forces producing instability are proportional to the size of the model. On the other hand, stress effects due to applications of load may be measured by the strains produced in a model of the same material, if the loads are proportional to the squares of the linear dimensions. The effects of applied load are studied even better in a model constructed of transparent material, since the variation of stress from point to point can be studied with much greater ease and certainty.

As detailed models of this latter kind present some variations from the usual laws of similarity, it may be of interest to indicate their nature. Questions of deformation clearly involve the elastic constants of the transparent material and their relation to those of the proposed structure, while stress distribution in the solid is influenced by the value of Poisson's ratio. This latter effect is quite small for glass, but may become appreciable with other substances. It is negligible in a model of any material which approximates to a thin plate stressed by forces in its own plane.

The optical effects for any given load are, moreover, independent of the thickness of the material, and depend upon the stress difference, so that color effects are obtained which may be regarded as pictures of shear stress throughout the model. Modern researches on ductile materials like structural steel indicate that such materials fail at some limiting value of shearing stress, and since the places where these limiting values are reached in the model are visible to the eye, the weak places in the design of a structure can be ascertained and a faulty design corrected by purely experimental means.

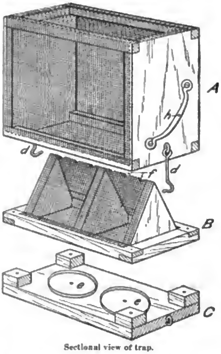
In this connection it is of interest to mention that M. Mesnager, the chief engineer of bridges and roads to the French Government, has recently constructed an elaborate model in glass of a design for an arched bridge of about 310 feet span. This investigation was considered advisable for a work of this magnitude constructed of reinforced concrete, in order to check the calculations, especially of maximum stresses in the arched ribs, which latter were assumed to be fixed at the ends.

The effects of reinforcements were allowed for by determining equivalent sections of glass for the members of the model. Many difficulties had to be overcome in the production of a model free from optical defects, but these were all successfully surmounted. The stresses in the model were determined by aid of a Babinet compensator, and formed a valuable check upon the calculations for a structure of this great magnitude and somewhat unusual design.

In this brief and incomplete account of a small branch of applied science relating to engineering the fundamental importance of discoveries in pure science is manifest.

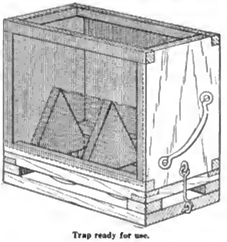
A Homemade Fly Trap

A RECENT issue of the *Weekly News Letter to Crop Correspondents*, issued by the Department of Agriculture, gives a description of a cheap and easily constructed fly trap that was sent to the Department by a farm demonstration agent in South Carolina, where it is being used most successfully in the work of home sanitation.



Sectional view of trap.

"These traps can be made any size to suit," says the department's agent, "but the most popular size in my work is 16 inches long, 12 inches high, and 8 inches wide. I also make some as large as 24 inches long, 18 inches high, and 12 inches wide. The material for these traps costs from 10 to 20 cents, and can be put together by anyone handy with tools in a short while." The trap may be baited with sour milk, a piece of banana, a fruit skin, or similar substance. This should be removed at night or it will attract ants. At the same time, the flies which have been caught should be killed by pouring hot water over the trap or leaving it immersed in water until the flies are died.



Trap ready for use.

The fly trap is made in three distinct parts *A*, *B*, and *C*, that may be detached from one another by unfastening the hooks *d* that hold them together at either end. The trap is unhooked in order to place the bait on the bottom section *c*. The bait is placed on two pieces of tin *e* tacked to this bottom section. In the sample trap that was forwarded to the department these pieces of tin were circular tops of paint or milk cans, which can be removed by prying up with a knife.

The middle section *B* of the trap consists of a screen-covered frame that resembles a small gable roof through which there are six holes *f* to let the flies into the uppermost section *A*, which is merely the screened-in cage that is set down over the other two parts *B* and *C*.

The handle *h*, of course, is unnecessary, but will be found convenient when the trap is immersed in water to kill the flies.

The department's agents, in their demonstration visits to the different farms, take the fly traps with them. They interest the housewife in them, and set one up in her home to show what it can accomplish. The results of the demonstrations have been so successful that almost every farmer who sees the trap wants one, and many of them have been putting traps together in accordance with the instructions of the agent.

The traps have done much to arouse the interest of the rural population of South Carolina in fly extermination, the necessity for which is not always felt so strongly on the farm as it is in the crowded city, where these vermin make themselves more obnoxious.

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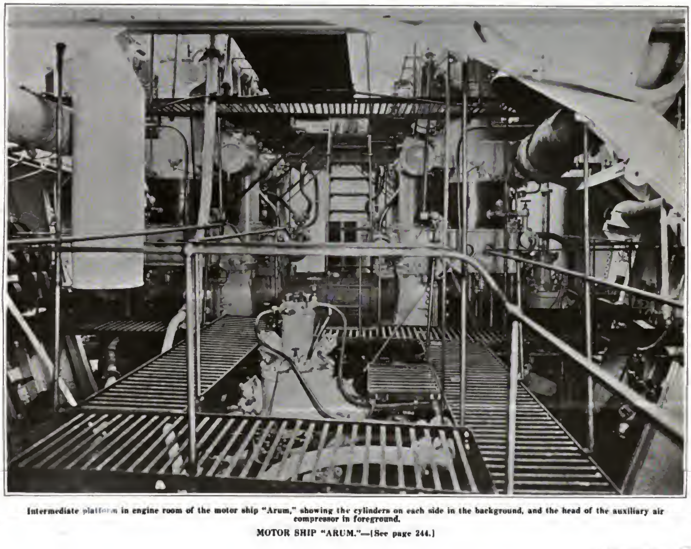
Motor ship "Arum." Powered with twin-screw Diesel engines.



Intermediate platform in engine room of the motor ship "Arum," showing the cylinders on each side in the background, and the head of the auxiliary air compressor in foreground.

MOTOR SHIP "ARUM."—[See page 244.]

The Germplasm as a Stereochemic System—II*

Every Individual is a Chemical Entity That Differs in Characteristic Particulars from Every Other

By Edward Tyson Reichert, University of Pennsylvania

Concluded from Scientific American Supplement No. 2023, Page 227, October 10, 1914

C. THE GERMPLASM A STEREOCHEMIC SYSTEM, THAT IS, A PHYSICO-CHEMICAL SYSTEM THAT IS PARTICULARIZED BY THE CHARACTERS OF ITS STEREOISOMERS AND THE ARRANGEMENTS OF ITS COMPONENTS IN THE THREE DIMENSIONS OF SPACE.

If, during the progress of development, there arise the multiple forms of differentiated protoplasm that are represented in the nerve cells, muscles, glands, etc., which exhibit such diversity of form, functions, composition and products, each part being correlated to other parts by the agency of tissue products, it is logical to assume that in the development of the ovaries and testicles these organs have been so specialized as to endow them with the attribute of producing a form of protoplasm that embodies in a germinal state the fundamental peculiar stereoisomerides and the peculiar arrangements or phases of the associated proteins, fats, carbohydrates and other substances which inherently characterize the organism; and, moreover, that owing to the influences of the products of activity of the various tissues upon these organs, such changes in the organism as give rise to acquired characters may, through the actions of modified or new tissue products or foreign substances, affect the operations of these organs and thus alter the germplasm and consequently become manifested in some form in the offspring. The ovule in its incipiency is conceived to be comparable to a complex unequilibrated solution in which changes go on until the attainment of full development, at which time it is equilibrated and remains inactive because of the absence of some disturbing influence, but in which energy-reactions may be initiated physically, mechanically or chemically, and proceed according to definite physico-chemical laws in definite directions to a definite end. As for instance, when a solution of boiled starch and diastase is at a temperature below the minimal of activity and the temperature is raised, causing immediate developmental activation; or when the equilibrated molecules of nitroglycerine are exploded by percussion; or when an equilibrated maltose-dextrose-maltase solution is rendered active by dilution with water.

The *nature of the germplasm* or transmissive material that serves as the bridge of continuity between parents and offspring has been the subject of speculation from time immemorial. Such hypotheses and theories as have been advanced have had reference almost wholly to its physical constitution or ultimate morphological structure. Most of them are micromeric, that is, they hold that the germplasm as made up of infinite number of discrete ultramicroscopic particles which are endowed with both determinate structural and vital attributes. A considerable degree of ingenuity has been displayed in their formulation. Thus, we have the "organic molecules" of Buffon, the "microzymes" of Béchamp, the "life units" of Spencer, the "plastidules" of Maggi, the "bioplasts" of Altmann, the "stirps" of Galton, the "gemmules" of Darwin, the "biophors" of Weismann, the "pangens" of DeVries, etc., each author attributing to the units certain inherent peculiarities. To the foregoing might be added particularly the conceptions that belong to the chemical category, such as the "chemism" of Le Dantec and the "physico-chemical" theory of Delage. Some of these conceptions are so fanciful in the light of modern science as to be unworthy of more than passing consideration, while none of them has led anywhere beyond the field of speculation and reasoning. Even the very recent and extremely interesting and important additions to our knowledge of the histological phenomena of the developing ovum, especially of the chromosomes, have not taken us appreciably nearer the ultimate constitution or mechanism of the germplasm, or even to the nature of the reactions which occur immediately antecedent to and cause the formation of the chromosomes.

A theory to be *ideal* must not only have as its basis well-defined principles that are consistent with facts, but also be capable of substantiation by laboratory investigation. Given as the basis of scientific study a germplasm that has inherently the power of development; that is in the form of a stereochemic system that is peculiar to the organism; that is highly impressionable to stimuli; and that has the marked plasticity that is inherent to organic colloidal matter, we have all the postulates that are needed as a foundation upon which according to the laws of physical chemistry can be built a logical explanation of the essential fundamental elements of the mechanism of heredity.

The *inherent potentiality* that determines the development of the egg along a line of definite sequential processes must be recognized as being common to both animate and inanimate matter and subject to the same laws, so that the phenomena of living and dead matter are inseparably linked and reciprocally explanatory. The typical condition of matter of definite composition is crystalline, and the crystalline form is the result of development that becomes manifested in a separation and orderly and progressive arrangements of components in the three dimensions of space. Having a homogeneous solution of various selected crystalline substances of appropriate chemical composition and constitution, and given conditions attendant to crystallization, the successive stages of crystalline development will proceed along fixed and definitely recognized lines, and the interactions and interaction-relationships between the various substances constituting the physico-chemical mechanism become obvious to a greater or less extent in the peculiarities of form, composition and other properties of the crystals. Having in the germplasm an analogous physico-chemical system, but one which is markedly different especially because of its organic and colloidal character and infinitely greater molecular complexity and sensitivity, the phenomena of development likewise proceed in conformity with the same laws along definite lines, but they are for perfectly manifest reasons more complex and varied, more difficult of analysis, and necessarily in many very important respects quite different. Each step in this orderly development leads not merely to changes of the physico-chemical mechanism by the modification, rearrangement, or splitting off of component parts, but also to alterations which automatically determine the characters of the next succeeding step, and so on to the establishment of physico-chemical equilibrium and the consequent termination of the reactions.

In living matter the chemical processes are dependent to a pre-eminent degree upon enzymes that are formed by the different kinds of protoplasm to serve as implements to carry out operations that are essential to their existence, and such enzymes are modifiable in quantity and quality in accordance with changes in internal and external conditions. The nature of both reactions and products of enzymic action depends upon the constitution and composition of the physico-chemical mechanism of which the enzyme is an integral part. Whether or not at each step of serial reactions a portion of pre-existing enzyme is merely modified or a new enzyme is formed which constitutes an essential part of the particular phase of the reactions is not known, but that one or the other occurs is apparently without question. It has long been established that some of the lower organisms, such as the yeast plant, have the property of modifying the characters of the enzymes produced in relation to varying conditions; recent studies of the animal organism show that the same phenomenon occurs in both tissues and blood; and our knowledge of the processes concerned in the catabolism and anabolism of complex substances, such as starch, is fully in support of such a conception. In other words, as each step of development is reached the alterations which occur in the physico-chemical mechanism absolutely automatically predetermine the characters of the changes of the next succeeding step, and so on to the end. Hence it follows that the peculiarities of any given physico-chemical mechanism predetermine the characters of the phenomena which ensue under given conditions.

An illustration of the probable *modus operandi* of such a mechanism is found in the phenomena of the synthesis and analysis of starch: During the production of starch through the agency of the chloroplast or leucoplast we conceive that there are instituted a predetermined orderly, independent and interdependent series of reactions, the first of which is manifested in an interaction between water and carbon dioxide through the agency of an enzyme in the form of an oxidase to form formaldehyde. During this process there is formed another enzyme, which tentatively may be designated an aldehydase, that reacts with formaldehyde and by polymerization and condensation of six molecules gives rise to a simple sugar, such as dextrose. At the same time, another enzyme appears in the form of maltase, which reacting with the dextrose causes the formation of maltose, during which reaction another enzyme, a dextrinase, is produced which reacts with the maltose to yield dextrin. Going on with this reaction another enzyme which may be designated an amylase appears, which reacting with the dextrin forms soluble starch. During this stage there arises another enzyme, a coagulase, which converts the starch from the soluble to the insoluble form or ordinary starch. At this stage the series of reactions have reached their end because a state of physico-chemical equilibrium has become established, the ultimate purpose of the processes being attained, that is a form of pabulum of extremely high nutritive value and of extremely low molecular pressure, even in soluble form, so that it may entirely and rapidly disappear without disturbance of physico-chemical equilibrium in the starch-bearing cells. The mechanism concerned in starch-formation is, without doubt, paralleled in the synthesis of proteins, fats and other complex organic substances, and it is but a step from the individual serial processes concerned in the formation of each of these substances to associated processes whereby there are formed and combined the various substances that constitute the organic structural components of protoplasm. Moreover, such serial processes are reversible at any stage, and so simple a modification as a change in the per cent of water may, as in the maltose-dextrose-glucase reaction, cause a synthetic change.

In vitro in both synthetic and analytic processes like those which constitute serial steps in the building up and breaking down of starch, protein, fat and other complex organic substances there does not occur in any reaction, as far as known, either a transformation or a production of enzyme such as occurs *in vivo*, hence, when a single enzyme is present it carries out but one step of the reactions, but when, as in the case of diastases as ordinarily prepared, the enzyme is not a single substance or unit body but a composite of a number of enzymes or modifications of a given basic enzyme, serial steps may occur as *in vivo*. Thus, if only a single enzyme be present, formaldehyde may be converted into a monosaccharose, or a monosaccharose into a disaccharose, or a disaccharose into a polysaccharose such as dextrin, or dextrin into a higher form of polysaccharose such as soluble starch, according to the enzyme or modified enzyme and initial substance present; or the reverse of any one of these processes may occur if proper conditions are present, but never do any two successive progressive or regressive steps occur unless through the agency of two different or modified forms of enzymes present.

It will thus be apparent that the first step of synthesis is determined by the character of the initial physico-chemical mechanism and that all subsequent reactions under given conditions are definitely predetermined; in other words, the entire train of reactions depends inherently upon the nature of the initial physico-chemical mechanism of which the enzyme that starts the serial changes is an integral part.

Having a specific stereochemic system, such a system in accordance with the laws of physical-chemistry can exist in either a latent or active state, and that when in an active state the reaction or reactions are always in the direction of the establishment of equilibrium of solution, every reaction or series of reactions being as definitely predetermined as is every reaction familiar to the inorganic chemist. The germplasm in the form in which it is secreted may be regarded as being in the nature of an exceedingly complex stereochemic system which is from its incipiency, or very soon, in a state of physico-chemical unequilibrium, and in which, as a consequence, reactions are set up which are manifested especially in histological developments that ultimately characterize the fully developed ovule, at which time a state of physico-chemical equilibrium is established, as is evident by the arrested developmental activities. This state of physico-chemical equilibrium of the matured ovule may be instantly changed to one leading to serial definitely predetermined reactions by means of an activating substance or condition, such as certain ions or inorganic salts, a spermatozoon, or a needle prick, by initiating the first step of the reactions, the nature of the succeeding reactions being predetermined primarily by the inherent nature of the physico-chemical system and secondarily by the factor that activates it. In other words, from this initial stereochemic system there arises a complex heterogeneous system that ultimately is morphologically expressed in the histology of the matured ovule and from which are formed a composite of correlated, independent, interdependent and differentiated masses which represent different phases of the components of the initial system

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Read by title at the meeting of the American Philosophical Society, April 25th, 1914, and in full before the Society of Normal and Pathological Physiology of the University of Pennsylvania, April 28th, 1914.

which have been modified not only physico-chemically as expressed by changes in physical, mechanical and chemical properties, but also in developmental energies; and from this composite are developed successively other systems.

Owing to the *great impressionability and plasticity* of such an exceedingly complex stereochemic system as the germplasm it follows that the germplasm must be extremely sensitive to changes in internal and external conditions, and that its operations and products may be so materially modified by changes in its molecular arrangements or components as to give rise to variables that are manifested in the transmutability of sex, variations, fluctuations, mutations, deformities, retrogressions, tumor formation, immunities, etc.

Assuming in accordance with our conception that the germplasm is in its incipiency an unequilibrated stereochemic system that is characteristic of the inherent, fundamental stereochemic system of the parent, it follows, as a corollary, that having a highly specialized form of parental structural material with peculiar energy-properties the offspring must of necessity possess essentially the same fundamental characteristics as the parents when normal fecundation has occurred, and that it would be quite as impossible to have any other result than in ordinary chemical reactions under given conditions of experiment. The essential characters of the building material as regards substances, arrangements and energy-properties are definitely fixed within narrow limits of variation.

That the peculiar forms of stereoisomerides or intimately related bodies that are inherent in the parent are conveyed in the germplasm to the offspring, and hence of necessity serve to distinguish a given form of germplasm from that of any other species or genus, and that the stereochemic conception of the nature of the germplasm is capable of laboratory demonstration, are instanced in the results of the investigations of Kossell and his students who found that simple forms of protein, known as protamins, obtained from the spermatozoa of different species of fish are different, each being apparently of a form peculiar to the source. Here is one substance at least that seems to be in specific stereoisomeric forms in the sperm of different species, which obviously must affect the properties of the germplasm, and which when brought in contact with the germplasm of the egg plays its part in determining the phenomena of development. Moreover, by the "precipitin reaction" method Blakeslee and Gortner have found evidence that is consistent with the conclusion that there are not only "species proteins" but also "sex proteins," and this receives support in a number of very recent investigations, especially those of Steinach who found that the corresponding hormones secreted by the ovaries and testicles are different, and that by virtue of these differences the secondary sexual characters, female and male, are determined. Thus, he found in castrated young males, in which transplantation of ovaries had been practised, that the development of masculine peculiarities is inhibited and female traits substituted, so that the individuals tend to assume the female type and become to a striking degree feminized-males, as shown in bodily form, in a development of the mammary glands, in lactation, and in an alteration of psycho-sexual characters. Furthermore, Riddle has found that the ova of the pigeon are dimorphic, one half having an inherent tendency to produce males and the other half females; that the eggs having the male tendency have a higher per cent of water, a smaller size, and a lower per cent of potential energy; and that the "sex-foundation" of the germplasm is transmutable, so that an egg that has inherently the male tendency may become female, and that such females exhibit secondary male sexual characters. The transmutability of the germplasm is comparable in its physico-chemical mechanism to the reversion of the maltose-dextrose-maltase reaction that is caused by a change in concentration of the solution, the dextrose being reverted into isomaltose and not to the antecedent maltose—the male egg is not changed into a female egg but into a modified or feminized-male egg.

In considering the transmissibility of parental substances it is essential to distinguish positively between the stereoisomerides and intimately related bodies that are *inherent* in the parent and those which are *acquired* through infection or otherwise. Thus antibodies that are acquired by the mother may be without influence upon the ovary during the formation of the germplasm and not even become a constituent of the latter. On the other hand, an immunity may be established in the mother that may be conveyed to the offspring, yet curiously enough such an immunity may not be transmitted by the immunized male. In processes of the production of the germplasm the ovary may be as insensitive to the presence of many acquired substances of the blood as are some or all other organs, and there is no more reason in general for expecting the ovary and its product to be affected by such bodies or conditions than there is for the pancreas and the pancreatic juice or any other secretory structure and its product to be affected. Every acquired substance must, in its relations to the ovaries, be governed by the same physico-chemical laws as determine specific selectivities or reactivities in connection with the tissues generally. Hence, any such substance may be reactive in relation to one structure but not to another.

Plasticity as regards sex-determination has been demonstrated in the studies of the development of a male (drone) bee from the unfertilized egg, and of a female from the fertilized egg. Moreover, the developing female bee when fed on ordinary food becomes a common "worker," but when fed on royal food develops into a queen.

The *continuity of the building material* between parent and offspring is seen in its simplest manifestations in reproduction among protozoa by binary fission and budding, by which the part separated from the parent mass is in all essential respects like the parent, having the same fundamental physico-chemical composition and constitution. That in such instances the offspring should be a segmental counterpart of the parent mass seems as obvious as that halves of a cube of sugar should be alike. Similarly, if we have in the ovule and sperm forms of protoplasm which as stereochemic systems are in all fundamental respects counterparts of those from which the parents were developed it follows that the offspring must under normal conditions in accordance with the laws of physical chemistry have the same fundamental parental characteristics, as much so as separated portions of any complex stereochemic system must possess the properties of the initial mass. Moreover, if the stereochemic systems of germplasms of the female and male differ, as must be admitted, it is manifest that the stereochemic system of the egg that has been activated artificially or naturally, as the case may be, must be different, and hence undergo development differences that will be obvious in the offspring. In the first instance, the serial reactions which lead to the formation of the different tissues, etc., are activated by a mere disturbance of physico-chemical equilibrium, which may be due to the conversion of a proenzyme into enzyme or a prosecretin to a secretin, or in other words of an inactive body into an active one. In the second instance, there is not only activation but the extremely important addition of the male stereochemic system which by admixture with the female system constitutes a female-male system. Therefore, in the first place the offspring is developed solely from the female stereochemic system, and in the second place from the combined female and male systems, one or the other of which may be wholly or in part dominant in determining certain peculiarities in the developmental changes. Moreover, owing to the transmutability of stereoisomerides and the multiphase transmutability of stereochemic systems, coupled with the reversibility of metabolic processes which may be due to even the simplest of changes in physico-chemical mechanisms, we have a logical basis for the explanation of the phenomena of sexual dimorphism that is expressed in the so-called male and female ova, and male and female spermatozoa; of primary and secondary hermaphroditism; of paradoxical sex developments where the unfertilized egg develops into either male or female offspring; and of sexual transmutability of the inherently male or female ovule.

It follows upon the basis of our theory that because of the inherent peculiarities of the stereochemic systems of the germplasms and the definitely predetermined nature of the entire series of reactions in accordance with the laws of physical chemistry that "like begets like" because like every other physico-chemical phenomenon, individual or serial, under given conditions, it is *a physico-chemical fatality.*

A French Experiment for Preventing Fogs

The municipality of Lyons has set aside a certain sum to carry on experiments for preventing local fogs proposed by M. Georges Onofrio, director of the Fourvière Observatory of that city. This well-known meteorologist has devoted much study to the fogs that cover Lyons for many days during the cold season, and has become convinced that these fogs may be lessened, if not entirely obviated. It may be noted, in contradistinction to general fogs that often cover plains of the north of France and the sea fogs that envelop many of the coast towns, that the Lyonnaise fogs are altogether local. Lyons, situated at the confluence of the two navigable rivers, the Rhône and the Saône, has a population of over half a million, and, although containing with its suburbs many manufacturing establishments, can in nowise be considered smoke infested. Frequently in winter the fog rises and filters through the streets, shutting out sunshine and causing discomfort to the inhabitants.

This fog is really an anomaly, because at a comparatively short distance away from the city there may be absolutely no fog. A strong wind will often clean the town of mist and bring a return of clear weather, whereas in cases of a general fog extending over a vast area a wind may be slow in bringing about a return of normal atmospheric conditions. Furthermore, according to the American Consul at Lyons, the fogs in that city do not spread widely, owing to elevated land about the rivers, and are often low-lying fogs. It has been supposed that local fogs were caused by the convergence at this point of winds from the north or from the Alps with those from the south. A chain of shallow lakes, lying upward of twenty miles away from the town, has been likewise blamed, as well as the dust and smoke inseparable from a large city. Careful observation, however, seems to point to the fact that the constant evaporation of the two rivers in and near the city produces a great deal of humidity, which is invisible when the temperature is high, but which readily condenses during cold weather when there is not sufficient wind to drive it away.

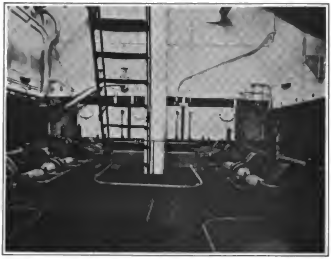
Owing to the heights along the rivers, this fog cannot escape except at one side, toward which a part rolls, thins out, and often disappears. In consequence, much confined, the fog thickens and increases in volume over the rivers, quays, and thoroughfares, and becomes injurious to health and interferes with traffic. At certain times the town seems from some points surmounted by an immense dome of mist, the density and height of which vary according to the temperature and the sunshine. In view of the possibility of doing away with the local fogs, the city authorities have determined to essay a systematic campaign against this plague. Certain measures have already been suggested, such as great blowing-machines from the heights above the city, and also the use of Hertzian waves. The project formulated by M. Onofrio consists in pouring oil on the rivers some distance above the city at a point where the fogs usually collect, so that the surface of the streams will be covered with a thin oil film for a distance sufficient to prevent the rise of vapors within the fog area.

Various facts have been collected from different points, showing the efficacy of the oil coats in reducing the roughness of water, escape of unhealthy odors, and the prevention of rapid evaporation. Experiments have been made by the scientist in question on a small scale with a long vat, at the end of which very hot water was introduced. At the other end there was an opening, so that there was a rapid and regular current. From the entire surface thick steam constantly rose. At about one quarter of the distance from the inlet a dividing partition was let down in the form of a double sieve, holding tow moistened with a small quantity of oil. Following the current, an oily coating extended over the lower three-quarters of the vat, and immediately vapor ceased to rise. It is estimated that a coating of oil of one 1/100,000 millimeter (the millimeter = 0.039 of an inch) in thickness is sufficient to cause the disappearance of the vapor from the boiling water.

This experiment was carried out with water at the temperature of about 185 deg. Fahr., whereas the temperature of the two rivers on which Lyons is situated averages about 59 deg. Fahr.; so it is believed that an exceedingly thin sheet of oil will be still more efficacious when spread over a cold surface, even should it attain the thinness of 1/200,000 millimeter. The thickness proposed for the rivers is 1/150,000 millimeter, which will require about 0.8 of a gallon for about every 460,000 square meters (552,000 square yards). The oil best suited to this work has not yet been determined. Trials are being made with as many as fourteen different oils—animal, vegetable, and mineral—to find one that will come nearest to fulfilling the required conditions. It should be an oil that will spread rapidly and easily over the surface of the water, and at the same time it must be an oil with the strongest possible power of resistance and tenacity. It is possible, however, that some special preparation will have to be devised to meet the conditions.

An oil film that will readily break on the water is of little value. These two qualities are more or less opposed, and it will require some study to find the oil that will spread most easily and still not break. It is thought that an animal or vegetable oil will be found preferable to a mineral oil, though the mineral oils would probably be a good deal cheaper. It is not possible to give the probable cost of keeping the entire city free of fog before an effective oil has been determined upon, although a rough estimate for both rivers puts the expenditure within £6 a day for the cold season. It is hoped, through the exhaustive experiments now beginning, to replace the average sixty-two days of fog with which Lyons is annually troubled by sixty-two days of normal weather. If practice bears out a plausible theory, not only will Lyons receive its full share of sunshine, but other inland cities similarly situated and darkened by fog will be enabled to profit by this simple fog-exterminating method.—*Journal* of the Royal Society of Arts.

Lower operating platform of the engine room of the motor ship "Arum," showing starting mechanism.



Upper platform in engine room of the "Arum," showing heads of cylinders and valve-operating mechanism.

The Motor Ship "Arum"

The Largest Diesel Engined Vessel Yet Built in England

Large vessels powered with internal combustion motors of the Diesel type are being built in increasing numbers abroad, and the largest vessel of this kind yet built in England, the "Arum," has recently completed a satisfactory trial and has proceeded to the East to take up her regular work. This ship is 300 feet long over all, 47 feet beam, and 27 feet deep, with a deadweight carrying capacity of 5,000 tons, and was built for commercial work in the Persian Gulf, a feature of her design being a spacious 'tween decks of eight feet, fitting it for the pilgrim traffic or as a military transport.

The special point of interest, however, in this vessel is that she is powered with a pair of Diesel oil engines which drive her through twin screws. These engines are of the Polar type, with modifications and improvements introduced by the builders, which greatly simplify the original design and add to the convenience of starting and maneuvering. They are on the two-cycle principle, and each engine has four cylinders 15.75 inches bore and 33.85 stroke, and at 123 revolutions a minute each engine develops 675 brake horse-power. Each cylinder is provided with its own individual scavenging cylinder, and as this is placed below the main cylinder, this construction makes the engines of unusual height, but they operate very smoothly, with little vibration. All of the valve gear is very simply arranged and is so well inclosed that few moving parts are visible, and many of the complications usually seen in the reversing gear have been avoided. The important point in large engines of this kind of cooling the pistons is accomplished by forcing sea water through telescopic tubes into the bottom of the piston rod, but in this case it seems to have been impossible to make the numerous connecting glands properly tight. The exhaust is so arranged that it can be either passed up the regular ventilating funnel or under the donkey boiler, which supplies the auxiliaries with steam. Each pair of cylinders is provided with a three-stage air compressor, and lubrication is by gravity.

Cargo is carried in four holds, each fitted with specially large hatchways; and under the cargo holds and in the fore and after peaks there are compartments for either water ballast or fuel oil. In addition to these, fuel tanks have been fitted on deck and in the machinery space, thus providing for an ample supply for long voyages. Suitable arrangements have been made for heating the oil when necessary.

The "Arum" was built by Swan, Hunter & Wigham Richardson, Ltd., who were also the builders of the engines. On its trial trip the vessel made 10½ knots, which was considered satisfactory. These engines are of the "Neptune" type, and are modifications and improvements on the motors introduced by the Aktiebolaget Diesels Motorer Company of Stockholm.

First Aid to the Wounded in War

That the eventual healing of a wound is largely a matter of the first treatment it receives is well known. The sooner it is protected from the air the less likely is it that complications due to infection will ensue. Even savages will attempt to close a wound with a bit of cloth, with moss, leaves, or even earth. But such materials of course commonly contain germs of such dangerous diseases as tetanus, septicemia, etc. Consequently all modern armies supply each soldier with a packet containing bandages which can be applied by himself or a comrade pending the arrival of the ambulance and the surgeon. At the December meeting of the French Society of Military Medicine, one of the subjects of discussion was the improvement of the first aid packet hitherto employed, containing a tuft of tow, a gauze compress, a bandage, a piece of waterproof cloth and two safety pins, the whole being chemically purified and impregnated with a 1:3000 solution of bichloride of mercury. The imperfections of this type have long been recognized, and Surgeon-Major Legrand presented to the society a new packet devised by Pharmacist-Major Fétel. This is described and discussed by Dr. Piussan, the Chief Surgeon of the French Army, in the *Revue Scientifique* for August 2nd.

In the first place, the bandages are doubled, since wounds from a firearm are usually double. Another point made is that antisepsis is illusory but *asepsis* is all important. Maj. Fétel's bandage is placed, before any attempt at sterilization, in a first envelope of filter-paper and this point is insisted on as a necessity in the manufacture. Dry heat at 138 deg. Cent. does not destroy the spores of anthrax or of the *bacillus subtilis*, and only a temperature of 120 deg. Cent. in water vapor under a pressure of two atmospheres gives full security. After being dried in a vacuum, the bandage is placed in an impermeable envelope, and for this Maj. Fétel proposes an enameled cloth which will resist a dry heat of 140 deg. Cent. for 30 minutes. This envelope is closed by a narrow band of the same cloth sealed with aseptic collodion (cellulose in acetone). This packet is then placed in a waterproof pocket closing with snaps. Maj. Fétel also proposed to add in an exterior envelope a small vial containing a cubic centimeter of tincture of iodine. This was criticized as being inadequate, though good in theory, and Dr. Piussan adds that the disinfection of wounds can be thoroughly accomplished only by the nurse or surgeon, and the first bandage should be merely for protection.

Dr. Piussan also quotes with approval the report made by Dr. Sallus, Director of the Service of Hygiene of the Sixth Army Corps, who had the happy idea of consulting all the doctors of the corps and combining their ideas. This report appeared in the April number of the *Archives de Médecine Militaire* and contained the following recommendations:

A. The packet should be rectangular, 12 by 10 centimeters, of a weight of 50 grammes, in a triple envelope.

(1) Exterior envelope of strong cloth easy to open by pulling a string.

(2) Interior envelope of parchment paper or enameled cloth in the form of a portfolio, closed and sealed.

(3) Two bandages, each enclosed in filter paper and composed of a wad of tow or absorbent cotton 10 by 10 wrapped in a doubled layer of gauze, folded in half and surmounted by a band 3 meters long by 0.08 centimeters in width, fastened lightly to it at 10 centimeters from its extremity. The other end split for a length of 30 centimeters.

B. The bandage must be aseptic.

C. It is advisable that the special pocket in the soldier's uniform containing the packet should be lined with waterproof cloth.

Dr. Piussan offers the following comment on this proposal:

"We fear that this bandage, so scientifically prepared, would prove a poor covering for the wounds it is designed to protect; moreover special instruction in its use would be needed. A bandage 3 meters long would not well keep in place a band which was slipping. Undoubtedly a better means to this end would be found in rubber-coated adhesive plaster."

Speaking further of the bandages provided in the ambulance service, Dr. Piussan observes that the method by which they are retained in position is of critical im-

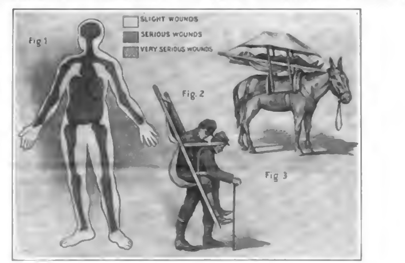


Fig. 1.—The division of wounds according to location shown in the human body. Fig. 2.—Contrivance for transporting wounded man on the back of a hospital orderly. Fig. 3.—Method of carrying the wounded on mule back.

portance, since ordinary bands are extremely liable to become displaced in long transports. He says:

"Dr. Cahier was the first to propose, in 1907, leucoplasts, bands of white rubberized cloth, then manufactured in Germany. These have a very great agglutinative power. Maj. Billet, of Val-de-Grâce, has newly raised the question of adhesive plaster before the French Society of Military Medicine. He has experimented with this idea which is not very recent, since Von Oettingen, in the Russo-Japanese war, made use of a mastic liquid with a base of alcohol and turpentine. This liquid became the '*Mastisol*' so largely employed in the Balkan war. It is very adhesive, and the gauze of the bandages remains fixed fast to the skin around the edges of wounds bathed in it.

"Maj. Billet prefers the adhesive plaster of the leucoplast type to these liquids which form a crust over the wound, and prevent proper drainage. Two rectangles of gauze are applied to the wound and then a slightly larger square of linen. Four bands of leucoplast fasten the edges of the bandage to the skin. A fifth band may be placed crosswise for security. The leucoplast, which is an adhesive band, is very neat, easy to put on, and keeps its position firmly.

"Maj. Reverchon, also of Val-de-Grâce, made use of leucoplasts at the Uskub Hospital. The Servian physicians are in the habit of using them, and Maj. Reverchon is a warm advocate of their use. Different types of leucoplasts are manufactured in France. In 1912, Dr. Filiâtre invented a transparent bandage which merits mention for its originality. It is composed of a rectangle of a special substance called cellophane, which is flexible and transparent and is sterilized in the '*Autoclave*.' This is placed on the wound and fastened to the skin at its edges by a band of rubberized adhesive plaster treated with oxide of zinc (leucoplast)."

Dr. Pinssan considers this "occlusive bandage" as quite perfect for use in operative wounds, which are clean-cut and aseptic, but not adapted for wounds received in battle, which are to be considered as infected *à priori*. However, the facility of observation will cause it to be retained in certain cases. He advises, however, the adoption of the leucoplast as soon as possible, saying that in the last war it was only too common to see bandages which had slipped, leaving the wound unprotected.

Projectile Photography

Easily Arranged Apparatus for Studying the Flight of Bullets

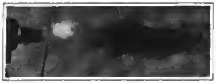
By Norman Burden

NEARLY all of the fascinating work of photographing projectiles in flight has been done in large laboratories, and those interested in this subject have felt that they had not the required apparatus for such experiments. Now the purpose of this article is to set aside these ideas and to give a clear idea of the whole operation. It may well be said that any student attending a school or college possessing a physics laboratory can succeed in obtaining good negatives of projectiles in flight. As a rule the most serious drawback is the lack of an induction machine, but it is quite possible to use an induction coil in its stead. In the following lines a description and explanation of the complete operation as carried out by the writer in the physics laboratories of the East High School of Minneapolis, Minn., will be given.

The apparatus used in this method of photographing projectiles in flight consisted of an induction machine, a battery of Leyden jars, a spark gap, large condensing lens and a camera. A view of the complete apparatus arranged in a working condition is shown herewith. At the extreme right will be seen the gun clamped rigidly to the table. Placed on the table to the left and back of the gun is the induction machine. Just to the left of the static electric machine is the battery of Leyden jars. Then further to the left is the spark gap, directly in front of which are the condensing lens and camera respectively. The framework which shows near the Leyden jars is a device for holding two wires by means of which the spark is caused to jump at the spark gap by the bringing of the two wires referred to in contact with one another. The whole operation is carried on in a perfectly dark room save for a dim ruby light. The arrangement of the apparatus is clearly shown in the accompanying diagram.

Arrangement of the apparatus for photographing a bullet in flight.

The arrangement of the apparatus is as follows: The gun is first clamped tightly in a rigid position. Then a target for stopping the bullet is put in position. A target can be made either of blocks of wood or by tying several thick magazines together. Before arranging the rest of the apparatus the path of the bullet must be found. This is done by placing two pieces of cardboard in vertical positions in the apparent path of the bullet. Put one about a foot in front of the muzzle of the gun and the other a foot to the far side of the point where the camera is to be placed. A shot is now fired, puncturing each cardboard. Now by sighting through one hole in the cardboard to the hole in the other, the path of the bullet may be located to a nicety. The next piece of apparatus to be set up is the framework for holding the contact wires or strips in the path of the bullet. The contact wires are placed vertically and must be exactly in the path of the bullet. For the contact wires or strips No. 35 copper wire or leaf copper wire will serve the purpose very well. Having put the framework in the proper position proceed to place the spark gap and the condensing lens and camera in their positions. There can be given no definite measurements for the placing of the last named pieces of apparatus, as different experimenters will probably have different kinds of instruments. However, it is best to place the condensing lens, which should be five or six inches in diameter, about two inches from the path of the bullet. Set it on the side on which the camera is to be located. A condensing lens having a focal length of about six inches will be found to be very well suited for the purpose. Now put the spark gap at such a distance from the lens that the pencil of rays converging from the lens will be brought to a focus at about eighteen inches from the path of the bullet. Then place the camera so that its lens is at the focus of the pencil of rays just referred to. The camera should be focused on the path of the bullet in order to get a sharp image of the projectile. The optical axis of the camera ought to be perpendicular to the path of the bullet, and the spark gap placed on this axis; also the axis of the condensing lens should coincide with that of the camera. For a clear idea of the arrangement of these pieces of apparatus consult the diagram. Set the Leyden jars and the induction machine in any convenient position. By following the arrangement in the diagram a great deal of unnecessary wiring and a large amount of electrical leakage which is at times very troublesome will be avoided. Connect the machine with the Leyden jars and the jars in series with the spark gap and the second break, thereby making two breaks in the circuit. For the connecting wires annunciator wire may be used; but it should run from one connection straight to the other. Wherever the wires are to be supported they must be highly insulated. Pieces of glass tubing are very convenient to use. Also wherever a wire might touch anything which might give way to leakage or a short circuit, insulate it with glass tubing or mica. Having put the apparatus in a working condition proceed to try out the experiment.



The bullet emerging from the muzzle. Note the smoke preceding the bullet.

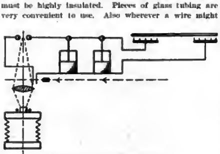
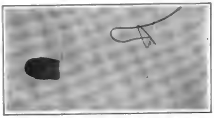


Diagram of electrical connections.

First of all see that the contact wires are placed exactly in the path of the bullet, and that they are about a quarter of an inch apart. Bend one wire so that the other will surely come into contact with it. Adjust the spark gap so that the terminals are about a quarter of an inch apart. Now operate the machine until the current jumps through both breaks. Do this several times and look for defects in the wiring. On finding everything all right, stop the machine and fully discharge the Leyden jars. Now find out how many turns of the induction machine handle will charge the jars so that they will discharge through both breaks. Do this several times, discharging the jars between each trial, and find the average number of turns. Now try it again, but this time give it four less turns and then push the contact wires together with a glass rod or other good insulator. If the spark is produced at the spark gap when the contact wires are brought within a sixteenth of an inch of each other, the current number of turns has been found. Now load the gun and cock it ready for firing, turn the handle of the static machine the correct number of turns and at the last turn fire the gun. At the same time watch the spark gap to see if the spark was produced or not. After having put all the apparatus in a working condition try a plate.

Nothing has been said heretofore regarding the kind or size of plates or the kind of camera to be used. For the camera one with a lens of large aperture is preferable to one of small aperture. However, the lens of almost any camera may be used if the pencil of rays coming from the condensing lens is focused exactly upon the center of the camera lens. For the plates, fast ones are best to use, and the faster the plate the better the picture. The writer used Lumiere Sigma plates with good results. The plates should be large enough to show about four of five inches of the path of the bullet. By consulting the illustrations it will be seen that the contact wires were placed so that they just showed on one side of the plate, thereby leaving the rest of the plate to catch the projectile.



The bullet in flight; muzzle velocity, 903 feet per second.

After exposing the plate develop it immediately or in a short time. Use any reliable developer and use a solution of such strength that developing will not have to be carried on for more than five minutes. Fix the plate in a strong acid hypo solution, and let it fix about twice as long as it takes it to clear. Wash the plate thoroughly and dry it in such a position that the dust will not settle upon it. It will be found convenient to make the dark room in which the experiment is carried on, serve as the photographic dark room. This saves a great deal of time as well as trouble. If the foregoing instructions are followed, the writer feels confident that there will be no great trouble in obtaining good negatives of projectiles in flight. A great deal depends upon the experimenter, and he must depend upon himself to correct some possible defects which might arise from his own methods of wiring and arranging the apparatus. There is still a large amount of knowledge to be gained by this fascinating work, and it is within reach of a great many who do not realize the possibility of their carrying out this experiment.

In one of the illustrations, at the left is seen the muzzle of the gun and the projectile which has just emerged from it. Around the back part of the projectile are seen the jets of expanding gases. The volume of smoke and gas which precedes the bullet from the barrel is shown very plainly. The white streak is the spark between the contact strips. Many interesting and instructive pictures of this sort are in reach of those who follow the foregoing explanations and instructions.

The writer wishes to say that he is greatly indebted to Prof. J. R. Towne of the Department of Physics at the East High School of Minneapolis, Minn., as it was through his kind permission that the use of the laboratories was obtained for carrying out this interesting experiment.

Climatic Influence of Forests*

Results of the Destruction of Timber on Climate and Soil

By L. A. Fosbery

The problem—if problem it is—regarding the effect that forest growth may exercise upon climate and rainfall, is one that has not, to any great extent, been brought within the purview of meteorological science; but, although precise data, accumulated within historic times, is wanting in this direction, the deductions, derived from close observation of cause and effect, as supplied by experience gained in other countries, are not wanting to present a strong argument in favor of the contention.

Without venturing to enter upon a disquisition on meteorological phenomena, it may briefly be stated that the greater importance of the question to Australia, than perhaps to any other country, is chiefly due to the geographical position occupied by that portion of the Continent lying between the 20th and 30th degrees of latitude.

These latitudes, common to both hemispheres, embrace the anti-cyclonic zones or high pressure belts encircling the globe; but, unlike other countries that possess the physical features of mountain, river, and forest, which make for cooler air currents and greater humidity, Australia's center has but few modifying influences to protect its central regions from solar action, and to assist in the formation of cyclonic disturbance and regular precipitation of moisture.

The radiation of heat from exposed earth and rock surfaces assists in the formation of the high pressure area which the heart of the Continent especially favors, and which, by its drying influences, extending far into the settled regions, tends to spasmodic and irregular rainfall, and aggravates the intermittent conditions of drought which prevail to a greater or less extent over vast areas of the country.

To what degree such adverse conditions can be ameliorated by human effort is a problem yet to be solved, but the active and persistent endeavor in every civilized country of the world to remedy the wasteful extravagance of the past by the protection of existing forests and afforestation, both for climatic reasons and the supply of human needs, offers an object lesson which the people of Australia have been too slow to follow, or perhaps too idle to heed.

Since the increase of cultivation and the general destruction of timber, many European countries have become perceptibly warmer and dryer within historic times, and premising that the loss of forest vegetation is one of the predisposing causes, the effects have been to increase the radiation of heat from exposed earth surfaces, to assist the rapid evaporation of moisture, and to give rise to heated and drying winds, which assume greater force and violence when unimpeded by forest growth.

These climatic changes have led to the conclusions that denudation of timber in the cultivated districts has proved a leading cause for the increased dryness of the seasons, the prevalence of violent winds, and the disappearance of the soluble constituents of the soil which have become exposed to the melting influences of sweeping and torrential rains. As a result of these deductions the closest attention has been, and is now being, paid in most parts of the civilized world—even in China and Japan—to the establishment and support of systems of forestry.

The United States—a comparatively young country—possesses nearly [illegible] acres of land under forest growth (nearly one fourth of its total area), and yet, despite the efforts now being made to reafforest denuded territories, a timber famine is predicted in the near future.

The State Forester of California has advocated a plan to protect water-sheds, under police power, from devastation by private owners that tend to injure the irrigation of lands lying below.

It has been argued by some that eventually wood will be replaced in many of our industries by iron and other substitutes; and this is held to be a substantial reason for the sacrifice of our forests to the advance of settlement; but apart from the consideration that must of necessity be given to the influences which timber has upon climate, retention of soil and water supply, and seeing that 2,000 years of civilization have not produced an efficient substitute, such an argument is fallacious.

ALL INDUSTRIES DEPENDENT UPON THE FORESTS.

The late President, in his address to the American Forest Congress, said: "The great industries of agriculture, transportation, mining, grazing, and, of course, lumbering are each one of them vitally and immediately dependent upon wood, water, or grass from the forest. The manufacturing industries, whether or not wood enters into their finished product, are scarcely, if at all, less dependent upon the forest than those whose connection with it is obvious and direct." In speaking again as to the importance of preserving timber in the vicinity of open country and great plains, the President said: "Wood forms an immensely portentous element in helping the farmer on these plains to battle against his worst enemy—wind."

The widespread effects upon climate and rainfall through general denudation of timber, whether it be for industrial consumption or for the demands of agricultural settlement, need no comment from those who believe in the climatic influence of forests.

Let us turn again to the observations made in other countries on this important subject. In one of the American Consular reports Mr. D. L. Partello, United States Consul for Dusseldorf (Prussia) says: "A great portion of the private forests has been devastated and made into arable land. In consequence of that, the humidity of the earth diminishes, and the land itself becomes more sterile. Besides that, the useful birds, losing their shelter and places for nests, decrease, insects multiply, and consequently the grain fields are seriously damaged thereby."

Edmund Jussen, Consul-General for the United States at Vienna, writes as follows: "The causes of the destruction of forests have been the same in the old world as in the new. The greed of men, the desire of speedy gain without reference to consequences, the want of judgment and knowledge as to cause and effect in the courses of nature, have shorn the forests along the spurs of the Alps and the shores of the Mediterranean with the same merciless energy which has been displayed in the direction along the shores of American rivers and on the slopes of American mountains. A great area of the shore provinces of this empire is now almost an arid desert. The result in a climatic direction has, as a matter of course, been highly disastrous. The same region which had been famous for its mild and temperate climate has become changeable and unreliable. The mountain creeks have become dry, and the whole face of the country has been changed from a rich, fruitful, and salubrious climate to an arid, sterile plain, interspersed with stony and parched hillsides, populated by meager sheep and their equally meager owners."

Having touched upon American forestry conditions and dismal forecasts, let us for a moment contrast the position occupied by our own State of New South Wales with that of the United States. Instead of 400,000,000 acres of forest area in the latter country—or one fourth of the whole territory—we possess but 20,000,000 acres of forest, the bulk of which is confined to the Pacific Coast, or less than one fifth of the total area of the State.

Pastoral needs have denuded vast areas, suitable for settlement, of timber, which, if the results of destruction had been fully realized, would have been left in appreciable quantity for the use of future generations.

Before the country has become populated the timber has disappeared, and is fast disappearing; how necessary, then, is it to preserve intact every acre of existing forest land in the interior, to assist in satisfying the needs of a coming people, and to stay, if possible, the climatic results of denudation which must inevitably follow.

The probable results that destruction of timber may have upon climate and soil are more especially marked in ancient centers of civilization than elsewhere.

Taking Assyria, Egypt, and other neighboring countries as examples, their monumental remains speak of dense population, both centralized as well as rural, whose needs for great periods of time must have been supplied from extremely fertile sources, necessarily—owing to primitive means of transport—from the surrounding districts. This condition of fertility necessitated the presence of forest growth, salubrity of climate, and a humid atmosphere consequent upon the existence of a luxuriant vegetation.

The physical condition of these countries at the present moment offers the strongest presumptive evidence as to the truth of the main contention.

Here, perhaps, a comparison may be drawn between the arid conditions of these timberless regions and other parts of the world, whose latitudes within the tropical zone should naturally intensify the effects of solar heat and corresponding aridity.

The valleys and tributaries of the Amazon, the Congo, and other great streams are favored by climatic conditions of humidity now almost entirely absent in the higher latitudes mentioned. The masses of aqueous vapor evaporated from these waterways, and exhaled from the dense forests which clothe these great areas, too far distant to be swept into the ocean by variable winds, and checked in their course by forest growth, are precipitated, mainly, within their own limits, thus giving to the climate of these regions the humidity and evenness of rainfall so necessary to render them fitted for the habitation of man.

Given the same conditions of human agency which, in the past, has swept away the forests from the ancient centers of population, would not these regions within the torrid zone present the same barren and arid features which we see to-day in many countries of the old world? If the answer is affirmative, the assumption is clear that the presence of forest growth is a dominant factor in the preservation of favorable climatic conditions.

The question has arisen, regarding the effect of general timber-killing on water supply, the effects of timber destruction on high steep lands on the margins of rivers and other watercourses, and the inducements they offer to floods and erosion.

RESULT OF TIMBER-KILLING ON RAINFALL.

Unlike other countries whose perennial streams are largely fed by melting snows from high altitudes, Australia is dependent for its surface supplies on local rainfall. It may be assumed that as humidity of atmosphere is inseparable from sources of evaporation and exhalation such as protected soil and vegetable growth, so, on the other hand, it may be concluded that the devastation of forests and the denudation of timber generally must result in a lessening rainfall and a diminution of surface water supply.

As timber disappears before the march of husbandry, the increased heat radiation from the earth's surface, laid bare by the destruction of its natural covering, acts as a deterrent to the precipitation of local rains; following which the naturally arid condition of the interior of this continent becomes aggravated under the deprivation of a natural supply of atmospheric moisture.

Ocean-borne vapors which penetrate beyond coastal limits under conditions of low barometrical pressure are precipitated upon bare surfaces with undue violence. The gentle absorption of moisture into the soil by seepage through the protecting humus of the forest is absent, and the rapid accumulation of water, thus permitted to flow unchecked, must render the land subject to conditions of sudden and disastrous floodings.

Timber-killing on high, steep lands leads to more disastrous results than can at present be conceived in a young country like Australia. Experience in this direction has not yet been fully gained, but the knowledge imparted by observers in the old world offers to us object-lessons which cannot with common prudence be neglected.

Touching on this point, and speaking of the devastation of forest growth in the western provinces of Hanover, Mr. F. Raine, Consul-General for the United States, says: "In the western provinces, which are rich in mountains, the fertile forest soil, the result of a thousand years of leaf and needle nourishment, has disappeared from the heights of the mountains. The scorching rays of the sun, wind, and storms, render the ground arid and unproductive. Rain and snow water have carried what little soil remained down into the valleys, and even the latter have not benefited. The crude and sterile soil of the mountain rubble and pebbles have followed, and filled the valleys with mud and fragments. Moisture is no longer returned to the atmosphere, neither by exhalation from forestal plants nor by evaporation from leaves and loose forest soil."

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* Read before the Royal Commission on Forestry, New South Wales.

Under forestal growth on elevated lands the rainfall is absorbed gradually into the subsoils, finding its way to the underlying rock surfaces along the roots of growing timber which penetrate to them, to break out again in springs, and to feed gently running streams along the valleys. The timber being destroyed and root-growth decayed, the surface hardens and offers no assistance to percolation. As a consequence the soil becomes channeled and eroded, being finally swept away in muddy torrents to silt up stream and river beds with sand, stone, and débris.

One great feature in Australian landscape scenery is the aspect of its beautifully rounded and gently sloping elevations, for the most part clothed to their summits with native forest growth.

The geological formations of this country are similar in many respects to those of the old world. Its mountain masses are subject to the same erosive action of moisture, wind, and weather as are those of other countries, and it may safely be concluded that in ancient times the now rugged, barren, and unfertile slopes of such mountain ranges as the Alps, the Pyrenees, Apennines, and numberless others were equally clothed, equally rounded, and as fertile in early days as our own hills are to-day.

RESULT OF DENUDATION.

The same results must follow the destruction of forests upon the slopes and summits of our hills bordering our fertile valleys, as experience and observation in other places have shown; and it must be remembered that, once lost, the soil can never be replaced. Under no condition whatever can reforestation take place in those localities, and no remedy can then offer itself for the evil that has resulted from human agency, its improvidence, its ignorance of cause and effect, or its wilful disregard of the courses of nature.

In the Tumut district of New South Wales one case in particular offers a striking example of present-day neglect. A landholder, with a view to increase the grazing capacity of his hilly lands, ringbarked the whole of the timber upon them, and for several years enjoyed the increased pasturage which followed this operation; but, as the timber decayed, the root-growth lost its prehensile grasp, the soil released thereby became loosened, and gradually left the summits, which have become denuded of every vestige of vegetation. This action will inevitably continue till these hillsides are stripped of their covering, and the intervening valleys filled with débris from them.

The forests existing along our river courses should be preserved by every possible means that legislation can provide.

It has been observed that margins of rivers fringed with forest growth enjoy a higher rainfall than the immediate hinterland of plain or cultivated lands. Whether this is due to an attraction which the presence of water may exert on rain-clouds, or to the impediment which timber offers to the swift passage of vapor-laden atmosphere, we are unable to determine; but, no matter what the cause may be, the fact remains, and for this and other reasons existing conditions should, if practicable, be maintained at all costs, and the waterways of the country remain protected along their margins by permanent vegetation. The shifting of channel beds, the silting up of rivers and streams, the filling in of depressions with silt, mud, and débris by the action of rains, are traceable to the denudation of timber along the courses of rivers and on adjacent cultivated areas, often resulting in impeded navigation and destruction of property.

The question has been asked: "To what extent is it practicable to sow or plant, or sow and plant in the very open tracts of country in the central and western divisions of the State, wide belts of timber, trees, and shrubs, approximately rectangularly to the course of prevailing winds?" This is an exceedingly difficult one to reply to in a practical manner.

TREE PLANTING IN OPEN COUNTRY NOT PRACTICABLE.

The semi-arid conditions prevailing over immense areas of these two divisions, the character of the soil, the prevalence of hardened and baked clay surfaces, sparsely covered in places with but a sprinkling of fertile soil, render the planting and sowing of forest plants, with a hope of satisfactory results, extremely problematical; in fact, it may generally be said that such an attempt in the more open country could scarcely bear serious consideration. The enormous cost of planting and sustaining young plant life, the impossibility of irrigation—at least for very many years—and the difficulties attached to the adaptability of plant-life to soil, present insurmountable obstacles to practical endeavor.

An alternative solution of the difficulty is suggested in the encouragement of native and the indigenous plant-life of the locality by natural rather than artificial means. It is a well-established fact that saltbush country, so-called in early days, will recover to a very considerable extent if protected from feeding by stock, especially sheep. Whether this is due to seed lying dormant in the ground or to root-growth still retaining vitality, or to both causes, the fact remains that the myall, saltbush, and many other saline growths will reappear on protected areas in favorable seasons.

In the years 1873-1878, following the wholesale ringbarking of forests over the bulk of our pastoral holdings, the young pine appeared, to reafforest by natural means the regions once occupied by pine forests. An immunity from destruction by bush-fires, owing to the overstocking of the newly-grassed country, resulted in dense growth of this timber appearing over large areas. This growth was unquestionably from dormant seed, but whether or not a further supply still remains, to spring into life within protected limits, experience and trial can only show.

NATURAL AFFORESTATION.

In the more open country, if strips of land from 5 to 10, and even 20, chains in width, and at distances from 4 to 6 miles apart, in parallel lines, were fenced and wire-netted as a protection from stock and rabbits, it is highly probable that the areas so set apart would resume the indigenous plant-growth native to the localities, and become useful as wind-breaks and as a check to the movement of soil, so prejudicial to pasturage and profitable occupation. Large areas in both divisions have become wind-swept owing to the absence of native shrubs, such as the salt and cotton bush, which at one time protected the surface soil, and this has resulted in a serious diminution of grazing capacity and a loss to the pastoral industry.

The denudation of native plant-life is also due to the improvidence of over-stocking, the destruction by rabbits, the trampling and loosening of the soil by stock, the melting influences of rain upon its soluble constituents, and the prevalence of high, dry, and heated winds, which remove the lighter particles in violent dust storms without check or hindrance. It has been observed, however, that as the smallest obstacle offered to the drifting of soil over compact and smooth clay surfaces will have a local effect in arresting the movement, so it may be inferred that barriers or screens erected at suitable intervals, rectangularly to the direction of prevailing winds, may have the general effect desired.

The prevailing westerly and northwesterly winds of summer would permit of north and south lines being adopted as the trend of such barriers. Existing netted fences on surveyed lines could be utilized with convenience, and at much saving of labor and cost. Absolutely straight or unbroken lines would not be imperative. Overlapping lines—although at considerable distances apart, where existing fences were not conveniently placed—would still present a front to the wind with the same general effect as an unbroken line. Thus a series of short, or comparatively short, barriers could be extended in a proper direction for indefinite distances.

In the western districts of Victoria the open plains in the neighborhood of Mount Elephant, Galla, Gallalabad, and Lara are subject to bleak and piercing winds during the winter months, and stock suffer proportionately; but, wise in their generation, many of the pastoralists planted strips of blue gum across the open country rectangularly to the prevailing winds, which have developed during the last thirty years into forest proportions, and now afford both shelter for stock and timber for domestic use.

In the more open country the natural growth could be supplemented by the planting and sowing of saline herbs and shrubs suitable to the climate and soil. The wind-borne soil would make a valuable seed-bed within and against these barriers, and various kinds of saltbush could readily be established. Although the plantations within would be efficiently protected from stock and rabbits by wire-netting, hedges of saltbush will extend their shoots through a fence sufficiently to afford a large amount of valuable food for sheep without injury to the parent stems; and it is reasonable to suppose that, when duly established, these food supplies would permanently and efficiently increase the carrying capacity of this class of country.

EFFECT OF BARRIERS.

The effect of these barriers would be to stay the progress of shifting soils, to break and cool prevailing summer winds, to modify the rigor of winter, and to offer shelter for stock. In addition to this, it might be hoped that the vegetation encouraged within the protected areas would result in a seeding of the land on either side of them.

Within the closer country the natural growth of the locality should be given encouragement to reassert itself through the protection afforded by these barriers or wind-screens; and if necessary the sugar-gum, fir, silky oak, and other quick-growing plants of a hardy nature could be planted where the maintenance of young plant-life would not involve too great an expenditure. In the pine country the young timber should be rigidly preserved and encouraged to grow within the barriers by natural afforestation. All green timber on existing roads should be preserved, especially on those running north and south, and where practicable the barriers might be erected adjoining them, so as to offer additional width to the screens and to assist as fire-breaks.

The steps to be taken in the formulation of necessary detail in connection with such a scheme would not present insurmountable difficulties.

As a work of supreme national importance, the Government would doubtless be prepared to meet the cost of so reasonable an undertaking; but, in such a proposition as presented here, every member of the pastoral and agricultural community should be prepared to join in support of it. It will be seen that if each landholder is made responsible for that portion of the work which touches his own estate he will see that it is faithfully done and properly maintained, both in his own interest and for the national benefit.

Although the Crown Lands Acts provide that the timber on certain classes of holdings shall be preserved to the extent of one sixteenth, the rule is more honored in the breach than the observance.

If a rule was made absolute that the outside boundaries of all holdings taken up under the Crown Lands Acts—in a depth proportionate to their respective areas—should be left in a green state wherever practicable, several beneficial results would accrue. Heat radiation from the cultivated areas would abate, living, and cooling screens would be presented to the heated and drying winds of summer, rapid evaporation would be checked, useful birds would remain, and exhalation from forest growth would, to a certain extent, continue. Timber for domestic use, firewood, and building material, would be available, and the general comfort of settlers upon such lands would be insured. In addition to the advantages above mentioned, these barriers and fringes of green timber would be found to act as efficient fire-breaks, to minimize the danger from widespread conflagration.

DECADENCE OF NATIONS THROUGH DENUDATION OF TIMBER.

As the whole of the inquiry into this vital question is directed to the comfort, well-being, and prosperity of man, and of a nation yet in its infancy, it may not be out of place to refer to a question which does not appear to have been seriously considered by historians: "As to how far the decadence and eradication of the ancient nations of the world are attributable to the denudation of timber?" It is certainly conjectural, but in studying the general laws which govern cause and effect it may be inferred that where, through the improvidence of a people, forests disappear, humidity becomes lost, fertility vanishes, and climatic conditions are so altered as to result in barrenness and absolute poverty of life-sustaining elements, man, deprived of sustenance, disappears with the vegetation he has destroyed. The sandy wastes of Arabia, Assyria, Babylonia, Persia, and Egypt, the once densely populated centers of high civilization, are examples which offer themselves to the thoughtful mind in this particular direction as a warning and a lesson.

Influence of Chemicals on Germination of Seeds

FARMERS and gardeners sometimes soak seeds in various saline solutions, or fumigate them with certain vapors, in order to preserve the seeds and protect them from insects. This process should not be applied ignorantly, for, while some chemical agents accelerate the germination of seeds, others retard or even prevent it. The neutral salts of the alkali metals produce very remarkable effects on seeds. A ½ per cent solution of potassium chloride prevents germination, and a 1/10 solution of an alkaline nitrate produces the same result.

This toxic effect, which is probably due to a reaction between the salt and the proteid constituents of the protoplasm, is strongest in the salts of caesium and lithium, and weakest in those of rubidium. Roots dipped in the saline solutions are very strongly attacked.

On the other hand germination is accelerated by very small doses of the sulphates of caesium, lithium, and rubidium. The strength of the solution should not exceed 1/100 per cent for caesium, 1/20 per cent for lithium, or 1/5 per cent for rubidium sulphate.

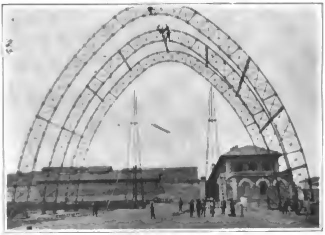
Carbon bisulphide, potassium bichromate, corrosive sublimate, copper sulphate and aniline, in exceedingly small doses, also accelerate the germination of seeds.
—*From La Nature.*

A Zeppelin dirigible coming out of the great hangar a

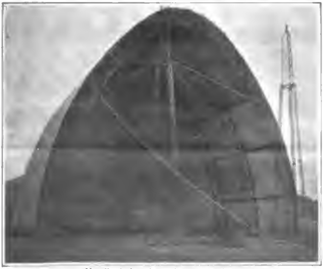
New Hangars for Military Uses

Portable Structures for Use in the Field

The question of providing suitable hangars for airships has received much attention in military circles in the leading countries of Europe, in order to keep pace with the development of airships for army use. Such hangars may be divided into two general classes, one of these being a balloon shed of the fixed and permanent type which is erected once for all and belongs to certain military aeronautic establishments. Up to the present it is the permanent hangar which has received the greater share of attention on the part of designers and constructors, but not less important is the type of movable shed which is also needed as part of the army material in order to give a suitable shelter for airships when carrying out military operations in various places where they may be at a considerable distance from any of the permanent posts. The question of a portable hangar has also been the object of research on the part of constructors, and we illustrate one of the most recent ideas of the kind which has been brought out in Italy, this being the Bosco and Donadelli system, and it is worthy of note for several reasons. As several of our engravings show, it has been tried in field work by the aeronautic corps of the army.

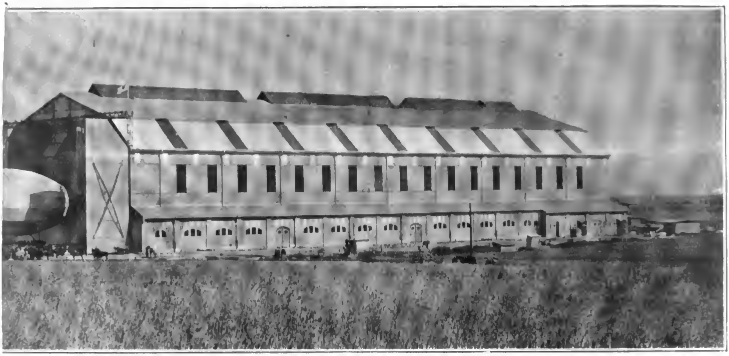


Each arch is built up in sections on the ground and is then raised into position.

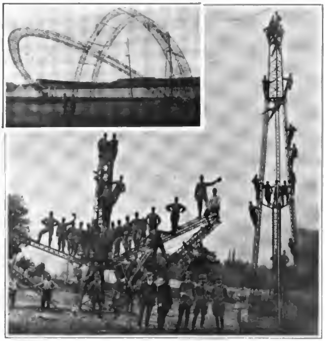


Metalized cloth is used as a covering.

The different sections which make up the arches are locked together by using a hinge clamp which is peculiar to the present system. Toothed projections on one piece fit into recesses on the opposite piece like the two halves of a hinge, so that when placed together, all that is needed is to run a pin through the matched holes in order to couple the two pieces. Each arch is made up of a certain number of sections which are thus joined together, and there are two separate hinge joints used at the meeting point. After locking one joint as we have seen, this forms a hinge so as to bring the other joint in place, and it is then ready to be locked as before by means of a pin, so that the two sections are tightly fixed together by means of the two joints. To dismount the sections, the only operation needed is to withdraw the two locking pins so that the joints readily come apart. In this way the arch is built up while it is lying on the ground, and is then ready to be mounted in an upright position. At the proper points on the ground the base plates are laid which form the foot of the arch. Each plate carries projecting lugs in the shape of a half-hinge. These are made to match with a like part on the arch end so as to make the joint. After running a pin through the hinge while the arch is lying on the ground, the last is raised to the upright position by using ropes and pulleys, and when in place, the second joint between base-plate and arch now matches, and this is fixed by driving in a pin, so that the arch is now fixed to the base-plate very strongly. The second arch is now raised in the same



logne—one of the largest of its kind in existence.



Arches in the course of erection. The pillars are built up of hinged sections.

way, and the two are bound together by cross brace pieces of structural iron work, as will be noticed, and so on until the right number of arches is erected.

Another point in the assembling of the hangar needs to be considered, this being the erecting of the structural iron poles or towers which are required in order to draw up the arches by means of cables. It has been a problem to set up such towers in the proper way in field work, as they must have a considerable height in order to serve for handling the arches and at the same time must be very strong in view of the great weight of the arch. The Italian constructors make use of the hinge joint principle in a very good way for mounting the towers. In the first place, a short structural iron pole is fixed on the ground upon the base plate so as to form the lower and center part of the tower. It carries a set of pulleys at the top for use in raising the rest of the tower in place. The base plate is triangular, and at each end of the triangle a beam of the tower is fixed by means of a hinge joint. This beam is in reality double, having a hinge placed at the middle upon its height, but both sections of the beam can lie on the ground owing to the hinges. All three beams come together at the outer or top ends and are hinged to a single top pole or cap. The whole can be assembled with the sections lying on the ground with the exception of the top cap, which fits down over the middle post. When the hinge joints are assembled, the whole is drawn to an upright position by ropes and pulleys, and in this position the second joints between the various pieces all come together so as to be locked in place by pins, thus making a three-sided tower with its cap-piece, and the whole construction is very solid.

On dismounting the tower, the men climb to the top and draw out one of the hinge pins at each locking point, leaving one joint which acts as a hinge as before. The tower is then lowered, as a whole, in the same way as it was raised. All these operations can be carried out in a short time. When the first two arches have been raised and bound together, the tower is no longer essential, for the arch structure can now take its place so as to carry the ropes for raising the other arches of the hangar.

A new fabric is used for the covering material, comprising a metallized cloth which has great strength and is also weather-proof. It hangs down at each end of the hangar as a double curtain which can be drawn apart at the sides. The dimensions of the new military hangar of the present standard type are 270 feet length by 100 width and 80 height. A very good speed in mounting is assured, and all can be put together within two days. When transportation by railroad is necessary, the folded metal work, with the covering and all needed parts, can be carried on a train of twenty cars.

An example of recent construction as regards the other class of hangars, that is the permanent balloon sheds, is shown in the type which has been erected at Cologne by the Augsburg-Nürnberg machine firm in order to house the Zeppelin airships. This hangar is noteworthy as being one of the largest of the military balloon sheds yet to be erected. One of the points which occupied the designer's attention was the operating of the large double doors at the end of the hangar. In spite of the great size of these doors, a suitable method of electric motor drive enables them to be opened in four or five minutes. The total length of the present hangar is very nearly 500 feet, its width 170, its height 112. The double doors are 82 feet high, and each door is 24 feet wide.

Power and Balance of Big Aircraft

THAT the large aeroplane of the future will be driven by two engines or more seems certain, not only from the point of view of increased reliability, but from considerations of an engineering character. The difficulty of concentrating the enormous weight of a power plant developing, say, 500 horse-power in a single spot without subjecting the machine's structure to excessive and dangerous stresses must be obvious enough, however desirable this arrangement might be in so far as flying efficiency and behavior of the aeroplane in the air are concerned. For structural reasons, therefore, the most important masses of the machine would have to be distributed, a process which would involve an increase in the lateral moment of inertia, which is not without its disadvantages, for while an aeroplane possessing considerable lateral inertia is not so prone to assume an unstable position as the result of a gust, it would clearly recover its balance, once this had been lost, more slowly and with greater difficulty. In this respect, fortunately, an increase in the size of aeroplanes has beneficial results, for all these large aeroplanes are stable in the most noteworthy manner. This is probably due to the fact that wind gusts are nearly always strictly local and of small extent, so that while a gust striking one wing of an aeroplane of small span might tend to upset it to a dangerous degree, a machine of huge dimensions would only be slightly affected, and would probably sail majestically through gusts and eddies in undisturbed balance.—*Daily Telegraph, London.*

The Relation of Light to the Proof of Documents*

Proper Illumination of Courts Necessary to Insure Justice

By Albert S. Osborn

I CAN think of no association that bears a name which affords such a temptation to the manufacture of figures of speech as an Illuminating Engineering Society. The name at once suggests the dark places that need your assistance. Every department of human activity does indeed need illuminating engineers, and what we all want everywhere and all the time is more light.

Light is an important factor in the proof of documents and light engineers can promote justice by making it easier to prove the facts regarding disputed documents. Anything relating to the subject of illumination that affects the quality of human vision is of vital importance in all forgery investigations. Justice has been defeated many times because court-rooms like cathedrals have been lighted with a dim light somewhat in harmony with some of the hampering old legal precedents. Partly because of poor illumination, judges and jurors in many instances have not been able to see properly, where the case depended chiefly upon visible evidence. This partial blindness in the past has been due in some degree to an ancient legal procedure that threw a twilight gloom around legal investigations, weaving such a network of restrictions about them as made it difficult to prove a physical fact. Strange to say, objections are still made to the use of the microscope, to photographs, and aids of every kind, and these objections, even in these days, are now and then sustained. All these old restrictions have been intensified by poor lighting and improper physical surroundings as well as by individual but unconscious deficiencies in seeing ability, for there is, in fact, a form blindness akin to color blindness.

When the necessity arises for proving a somewhat obscure physical fact by visible evidence, this whole question of human vision, with its defects and limitations, becomes a question of vital interest. In the first place, it is important to realize that seeing ability is not by any means the same with all observers. It is an encouragement to improve our sense of sight to realize that only part of our skill comes by Nature and that much comes from study and experience.

It is also helpful to consider just how it is that we actually see what we think we see. We all know that when we hear sounds we perform a mental operation and from these sounds infer certain things. From arbitrary combinations of sounds, for instance, we get an English word which conveys an idea, or from another combination a German word, and from still another combination we infer that a man is walking or a horse is running. When we see things, however, we are inclined to assume that we are receiving directly in the brain positive information instead of certain sensations which we must mentally interpret just as we have interpreted the sounds.

In much greater degree, therefore, than we are inclined to admit, it is no doubt true that we really see but little more than we are able to compare with some experience or standard that we already have in the brain. The savage does not really see a steam engine, or a watch, or a city, and in some degree we are all in the savage class. The thoroughness of this mental comparison and the final accuracy of sight depends upon two things, the force and clearness of the sensation that reaches the brain and the experience which the brain already possesses. The necessity for seeing clearly, therefore, is that we may interpret accurately.

This whole question of human vision and the aids that perfect and intensify it, is naturally closely related to the question of discovering forgery and the numerous other physical conditions that may point to fraud of various kinds in connection with disputed documents, and is of special importance in connection with the showing and proving of these facts in a court of law, often against prejudice, and usually with untrained men who must be made to see and understand. It is therefore essential that sense impressions of all kinds be clarified and intensified in every way possible, and the arrangement, distribution, and management of light has a most important bearing on the subject.

Under the old legal practice, now happily, but all too slowly, passing away, expert testimony regarding forgery and documents, involving as it does many technical interpretations of visible evidence, was mainly the giving of bare oral opinions on a contested question in courts of law. This practice, much criticised and discredited, still continues in certain cases relating to insanity and some other subjects that the ordinary man, no matter how assisted, is unable to pass upon intelligently. A new practice, however, has developed in most jurisdictions in connection with proof of physical facts relating to documents, by which referee, judge, and jury are actually shown the basis for whatever opinion is given, so that with the assistance of reason-giving testimony, now admitted in almost all courts, and with the aid of instruments, and enlarged, properly grouped photographic illustrations, they can finally reach their own conclusions regarding the disputed fact. Testimony is not simply oral, as in the past, but visible as well.

With the new and enlightened procedure and a court-room where seeing and hearing is possible, numerous surprising verdicts in cases of this class have been rendered. Three recent New York cases are conspicuous examples. In the first, four alleged eye-witnesses, two of them of irreproachable character, testified to the execution of a will and a jury decided it was not genuine; in the second, six witnesses testified that they saw a certain contract signed and a jury decided the document was a forgery; and in the third, a jury convicted a distinguished member of the bar of forgery of only two short words in typewriting that, by comparison, were shown to be written on his own typewriter.

It will readily appear that this change of practice regarding visible evidence makes necessary such an illumination of court-rooms or trial chambers as makes it possible to see with the utmost distinctness. To the end therefore that visible evidence in cases of this class, and in all kinds of cases, may be presented with the utmost clearness and force, it is highly important that an illuminating engineer be consulted in regard to the arrangement and lighting of every court-room.

Another reason why court-rooms should be properly arranged and lighted is to enable judge and jury to see witnesses with the utmost distinctness as testimony is being given as well as to hear them. That this result may be attained, it is necessary that witness-box, jury-box, and judge's bench be arranged in proper relations to each other and near together. Fortunately, there is in all of us a kind of instinct, enforced by conscious and unconscious training, by which we judge whether or not those who speak to us are telling the truth. This important faculty is dependent upon both the senses of sight and hearing. We recognize at once an insincere tone; even dogs and children judge us in an occult and unknown manner. By the use of the eye, as well as the ear, we unconsciously interpret all messages that come to us as exaggerated, true or false. That ancient requirement of the law that "the accused must be confronted by the witness against him" was no doubt in some measure based upon this important faculty by which truth is separated from falsehood. A witness should be placed close to and nearly, if not quite, facing the jury or the judge who is to decide upon the truth or falsity of his testimony, and the room should be so lighted that his attitude, appearance, and every changing expression is distinctly seen. Few of us have ever analyzed the evidences of sincerity and of untruthfulness as shown by hearing and sight, but we can understand how, at least to some extent, it can be done.

A visit to many a court-room is sufficient to show how such a room should not be arranged and should not be lighted. Artistic and architectural considerations, in many cases, would seem to be the only ones that had been consulted in the arrangement. In many a city of our land, of all places, the court-room is the one place where it is most difficult to hear and the most difficult to see, and the administration of the law could be greatly aided by the lighting engineer, the ventilating engineer, and the acoustic engineer. Trials should be held where every word spoken can be heard distinctly, and where every piece of visible evidence can be clearly seen for exactly what it is.

There are many court rooms so dimly lighted and so improperly arranged that it is almost impossible in them to prove forgery when such proof must be based upon the correct interpretation of delicate but highly significant visible evidence. In some few cases court and jury leave their accustomed places and in an informal and sensible manner gather around some well-placed, clean window where all can see and all can hear.

In connection with the proof of many different questions relating to disputed documents, correct and adequate illumination is absolutely essential if the facts are to be proved. Vital evidence is sometimes based entirely upon the interpretation of indistinct stains, or delicate tints or colors which, under the dim light provided, all become a dull and indistinct gray. In cases involving chemical erasures, in which certain indistinct yellow stains are of the utmost significance, such evidence is practically invisible under the yellow, flickering artificial light or the dim daylight of the average court-room. In many court-rooms the effective use of a microscope is simply impossible.

In many cases involving the identification of paper, where sheets have been interpolated in disputed documents, the case could be positively proven out in the court-yard, but under the conditions provided, intensified by the bad acoustic properties, injustice may triumph or the guilty may escape. Many a city in this land has spent millions of dollars on a court-house without one properly lighted and well arranged court-room where clear seeing and distinct hearing are possible. Darkness and evil have always been associated and still are associated in many a court-room. The modern laws of some states happily require a certain amount of properly placed light in every school house, but such laws, it would seem, have not yet been applied to the law houses.

Light is also a great aid to justice in connection with the subject of photography as now applied to the investigation and proof of disputed documents. To the modern examiner of disputed handwriting and documents, the photographic camera bears a relation to the business similar to that of the compass to the mariner. The relation of light to this question of photography is as close as the etymology of the word itself suggests. It writes out in a universal language its unmistakable interpretation of many things. Many disputed document cases are hastily settled as soon as they are properly illuminated by the photographic camera.

The camera assists us to see certain things which, without its aid, are too small for us to recognize in their true significance and force. It is one of the natural but erroneous human assumptions that we see all that exists before us; but we know that this is not true, and thus arises the necessity, in connection with many questions, of properly enlarging the thing to be observed. Many forgeries are perfectly apparent when enlarged a few diameters. The photograph also makes it possible to cut apart, group, and arrange the parts of a disputed document for effective study and comparison.

As is well known, the whole photographic art is based upon the arrangement and control of light, and certain hidden facts in a forgery can be clearly shown in a photograph by certain special arrangements of light. In a laboriously perfected forgery in which the lines have been carefully retouched and overwritten so that under ordinary vision the result seems to be perfect, a transmitted light photograph under proper enlargement is often sufficient to prove the fraud. By this means the varying thicknesses of the ink film itself are measured by measuring its ability to transmit light. If a line is retouched skilfully so that the edges are not broken or disturbed, such additions under ordinary vision may be invisible even under magnification, but a transmitted light photograph of such a stroke, enlarged from four to ten diameters, will show in permanent form with the utmost distinctness every added stroke. In making a photograph of this character the document is lighted partly from the front, but with the strongest light from the back, so that the light which makes most of the photograph is actually transmitted through the paper itself.

The transmitted light photograph is often more effective than the microscope to show retouching, but for preliminary investigations of this kind, and also for direct demonstration in court, the following special application of light is of great aid. A microscope table with a glass top having a strong light close underneath is provided. This combination is very useful, especially when employed in connection with the stereoscopic microscope. An arrangement of this kind in the leading banks of the land, available for instant use, would save thousands of dollars every year, as by its aid an experienced observer, in many cases, is literally able to "see through" a forgery. By this means light is literally thrown on the subject.

Another condition under which special illumination is of great value is in the interpretation of certain kinds of erasures, especially erasures of pencil lines. The disposition of thousands of dollars may depend upon the interpretation of a few words or even a few figures and the determination as to whether or not they have been changed. Unlike an ink line, an ordinary pencil mark is made by sufficient pressure on the writing instrument, so that a certain amount of graphite is worn off against the surface of the paper. If a mark of this nature is carefully erased so that the coloring matter is removed, it may become entirely illegible although the depression still remains, but is so shallow that it is invisible even under the microscope. If, however, such an erasure is photographed in enlarged form, with a strong illumination through a narrow slit on one side with the rays of light almost parallel with the surface of the paper, the shallowest depression, where a word or figure has been so effectually erased that it is totally invisible under any other examination, then produces a shadow which, in a photograph of this kind, sometimes shows with absolute distinctness what was originally written.

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* A paper read at the eighth annual convention of the Illuminating Engineering Society, Cleveland, O.

Another class of cases under which the question of perfect illumination is of vital importance is in all ink investigations, either to determine age, or to discover whether two or more ink writings are identical or different. Some of these questions can no more be answered under the illumination of certain court-rooms than they could be answered in the light of the average cellar; while the same investigation, if conducted under properly diffused white light, shows a result that can be seen and appreciated by any intelligent man. It is easy to understand how desirable it may be under certain circumstances to show that writing is not as old as it purports to be, or to show that an addition or interlineation in ink is the same or different from other parts of the same document. The interpretation must be based mainly upon the recognition of certain colors. Under suitable conditions and proper lighting this recognition is possible with the average observer. In many court-rooms such facts cannot be proved.

All ordinary commercial ink of the present day is a chemical solution to which a temporary blue color is added, so that the writing may be legible when first written. Fresh writing of this kind, as we are all aware, is of a distinct blue or bluish green color, which color gradually disappears as it is submerged or masked by the development of a stronger color from the chemical constituents of the ink, until it finally reaches a black or neutral gray. When used during the winter months, modern ink, under the usual conditions under which writings are kept, requires many months to lose all its initial blue color, so that examinations like those described, to show that the ink is not as old as it purports to be, may be made a long time after the actual date of the writing. Wills and documents representing hundreds of thousands of dollars are brought into courts of law purporting to be many years of age, on which the ink color has not yet reached its ultimate degree of blackness or intensity.

By the use of a special color microscope with two objectives and the Lovibond tintometer glasses it is possible to match and record this changing ink color with great accuracy. For example, it is easily possible to match more than a thousand variations in the color blue alone. If an ink of this class is accurately matched and recorded as it first appears on a document purporting to be several years of age, and then the same portion of ink is observed under the same conditions a few days or weeks afterwards, and the ink has distinctly changed from a blue or distinct purple to a black or a much darker color, this is positive proof that such document is not as old as it purports to be. Most persons can recognize colors under favorable conditions, but the recognition and matching of colors in an investigation of this kind in the ordinary court-room, under the conditions ordinarily provided, is simply impossible. If evidence of this class is to be made use of, it is necessary that the ink should be observed under diffused white light of the proper intensity.

Another most interesting special application of light that promises to assist in disputed document cases makes use of those strange new rays of the spectrum out beyond the violet. By the use of a suitable screen and appropriate illumination it is possible to photograph totally invisible stains resulting from a chemical erasure, so that the original writing becomes entirely legible.

Thus we see the advancement of knowledge in every field supplements that in every other field, and light engineers may be of great service in illuminating dark places in various divisions of human activity.

The Engineer and the Map of the World*

The one certainty regarding the result of the present war is that the map of the world will be greatly altered. The changes will concern the boundary lines of different nationalities, and will therefore be political. Even although the engineer has exercised great influence in providing the munitions of war which have so greatly assisted in the accomplishments which will inevitably lead to such changes, our purpose in writing now on the subject is rather to point to the material alterations in the map of the world resulting directly from the work of the engineer. By his agency land is converted into water and water into land. Rivers regularized and deepened, and artificial canals, affect the extent to which water-borne traffic can penetrate into the interior of countries. Railways, roads, and tramways have in other cases superseded rivers. Railways and roads are constructed, and traverse bridges across straits, whereby islands become ostensibly part of the mainland. Waterways are cut through isthmuses to connect oceans. By afforestation and deforestation vast changes are also made on the face of the earth, and through these and other agencies, influence is exerted on the climatic conditions, whereby the land is made more or less fruitful, the temperature being affected and the degree of moisture in the air altered. The health of districts is, by the same media, improved directly, while the advent of the engineer in many parts of the world brings in its train the scientist, with his investigation and work to combat fatal diseases, such as malaria, yellow fever, and the like. One has but to remember the improvement in the health conditions of Ismailia and at Panama to realize the immense consequence following the presence of the bacteriologist in association with the engineer. Mountains, deserts, and rivers have had their significance minimized by the advance of engineering. Mountains have been pierced, rivers bridged, deserts watered by irrigation, and forests removed or planted. Following tree-planting comes ploughing and harrowing and harvesting, and the desert blossoms like the rose. Industrial communities arise to meet the needs of the agricultural workers, and these again bring railways and other changes. Indeed, the practical every-day facts of the map take on a new meaning, owing to the advance of modern science. The term miles, for instance, has not the same significance as under the older forms of transport. To-day distances must be measured rather by the time necessary to get from point to point. Again, even such island empires as Britain and Japan may lose their isolation if tunnels are made, and submarine and aerial ships become tenable, for ordinary commerce.

In view of the war there is appropriateness in the suggestion of lack of finality in the work of those concerned with the political changes on the map of the world as compared with the continuous and permanent influence exerted by the engineer on geography. The presidential address, delivered to the Geographical Section of the British Association by Sir Charles P. Lucas, K.C.B., K.C.M.G., although prepared without any conception of the present international crisis, has an appositeness which is peculiarly impressive, as it deals with man as a geographical agency. It dealt with man's work in such departments of activity as irrigation, land reclamation, reservoir building, afforestation, etc. The damming of the Nile at Assouan, making a lake 65 square miles in area, with its immense practical, if not also political, advantage in the Soudan and Egyptian deserts, was referred to by Sir Charles Lucas. There was also indicated the corresponding irrigation work in India, which, in 1903, watered something like 48,750 square miles, a larger area than England and Wales together. Sir William Willcocks's work now in progress on the Euphrates and the Tigris, for irrigating nearly 19,000 square miles, at once rises to memory in this connection, while 4,000 square miles of the plains between the White and Blue Nile are to be watered artificially for cotton culture by the construction of a dam, and of a 100-mile canal south of Khartoum. In Australia, again, great work is being done to the same end. Already the works completed and in process of construction irrigate over 600 square miles in Victoria alone; but when the whole water supply of the State is utilized, more like 6,000 square miles will be irrigated. The Burren-juck scheme, in New South Wales, will irrigate, in the first instance, not far short of 500 square miles, but may eventually be made available for six times that area. In the Algerian Sahara desert nearly 22,000 square miles have been reclaimed with water from artesian wells. These facts show what has been done, and give confidence in the belief that still greater achievements will effect still more extensive changes on the face of the earth. By tree barriers in the sand dunes, whereby the moisture of the soil is preserved, fine crops of durum wheat, it was further pointed out by Sir Charles, are got without a drop of rain from seed time to harvest. In the Landes of Gascony 3,600 square miles of sandy waste have thus been planted with trees. The influence of all such works to assist agriculture is not only direct, but there is a great indirect gain; a consequence is the settlement of a population more or less extensive, due not only to the winning of the produce of the land irrigated, but to the creation of railways and factories for meeting the needs of the people. In this way, as the stories of Canada, South Africa, and Australia testify, communities are built up, and new nations grow steadily in prosperity.

The map has also been changed by great reservoirs for the water supplies of cities—Thirlmere, Vyrnwy, Loch Katrine, and those for Birmingham are cases in point. In the last session of Parliament there was vigorous opposition to the flooding of one of the historic districts of Scotland further to augment the water supply to the city of Glasgow. Abroad there are many similar instances, the most recent being the formation of a great dam on the Murrumbidgee River for New South Wales, to make a lake forty-one miles long, and the Catskill Reservoirs for the supply of New York, recently fully illustrated and described in *Engineering*. In his address, Sir Charles Lucas referred also to the importance of natural waterways, the Clyde, the Tyne, and other such streams, on whose banks there have been created great factories to produce articles for export through the waters of such rivers to the farther ends of the earth.

In the reclamation of land the engineer has exercised an equally great influence on the map. That the engineer in such work has greatly affected geography is proved by the example of London alone, since the metropolis is built partly on marshy land. Some city names, indeed, prove this, notably Moorfields and Finsbury (or Fensbury). With the work begun in the sixteenth century that part of the city has been recovered from the marsh lands. Pimlico is largely built on piles, and in the region now occupied by Belgrave Square snipe shooting was a sport three or four generations ago. The names of the Strand and Fleet Street also carry their significance. Even in new countries there are analogous cases. Harbors, such as that at Wellington, in New Zealand, have been partly reclaimed from the sea. Sir Charles Lucas also referred to the work done in the Lincolnshire Fens, where land variously estimated in extent from 800 to 1,200 square miles has been recovered or improved. Another instance of reclamation at home is to be found on the famous Romney Marsh, in Kent. Abroad one of the most extensive cases is that in the Netherlands, where there has been a constant change between land and water area; the Dutch people have steadily worked toward reclamation, and even at the present time the progress of the scheme for draining the Zuyder Zee proves the far-sighted policy of the government. The scheme is to be carried out in thirty-three years at a cost of nearly $80,000,000, and will result in an addition of 845 square miles of land to the kingdom, 750 miles of which will be fertile, while at the same time a much-needed fresh water lake, with an area of 557 square miles, will be formed and will be fed by one of the mouths of the Rhine. Between the Elbe and Scheldt more than 2,000 square miles have been reclaimed from river and sea in the past three hundred years.

Touching upon afforestation, Sir Charles Lucas did well to point out, as did Mr. G. P. Marsh fifty years before him, that man has too long forgotten that the earth was given him for usufruct alone, not for consumption, still less for profligate waste. The sweeping away of great forests, a practice even more pursued to-day than ever before, is undoubtedly the eating up of capital. Apart altogether from the value of the timber, trees give shelter against the wind, store water, prevent inundation, and preserve and enrich the soil. It is true that experience in the south of France has proved that the pasturing of sheep is as great a destroyer of forests as man, because they break the soil and expose the roots, so that rainstorms and floods sweep away the soil. This may easily be remedied, but the cutting away of the timber without replanting of trees is reprehensible. It has been suggested that, in view of the possible degree of unemployment in this country consequent on the present unsettled state of affairs, the British government might utilize the occasion for carrying into effect the afforestation scheme approved by a recent commission of inquiry, a point not enforced by Sir Charles Lucas. This proposal, it will be remembered, aimed at the planting annually of 150,000 acres of suitable land, and the result might probably be a valuable source of revenue ultimately for the government. It is thought this would afford temporary employment to men out of work and not suited for the army, while permanently many men could be utilized directly in connection with the forests and indirectly with the subsidiary industries. The commissioners estimated that the annual cost would be two millions sterling, and each year there would be an increasing deficit in working operations for the next forty years. Then revenue would be derivable. From this date onward the commissioners estimated that the deficit would steadily decrease, until in eighty years there would be, from 9,000,000 acres of forest then existent, a net revenue of about $87,000,000. The scheme thus expressed is seductive, but the figures are only estimates. That we are deficient in forest lands is shown by the fact that the proportion to the total area of the country is 5.3 per cent, as compared with 32.6 per cent in Austria, 17.3 per cent in Belgium, and 17 per cent in France. At present, under the auspices of Birmingham University, and under the presidency of Sir Oliver Lodge, the Midlands Reafforestation Association is planting the pit-mounds and ash quarries of the Black Country with trees which will resist smoke and bad air—alders, willows, poplars—carrying out their work, a report says, under a combination of difficulties not to be found in any other country. Thus, apart from the direct gain in the growth of timber, the work of afforestation confers great indirect advantages, and serves further to prove that from first to last the engineer is exercising an important influence on the map of the world, as well as upon the significance of geographical terms. Sir Charles Lucas has done well once more to direct attention to these important considerations.

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* From *Engineering*.

Explosives*

The Various Materials Employed and Methods of Using

An explosive is a body which, under the influence of heat or shock, or both, is, speaking popularly, instantaneously resolved entirely, or almost so, into gases.

Practical explosives consist either of bodies such as nitroglycerine and nitrocellulose, which are explosive in themselves, or mixtures of ingredients which separately are, or may be, non-explosive, but when intimately mixed are capable of being exploded.

Explosives are exploded either by simple ignition, as in the case of black gunpowder, or by means of a detonator containing mercury fulminate.

The molecules of an explosive may be regarded as in a state of unstable chemical equilibrium. A stable state of equilibrium is brought about by the sudden decomposition of the original compounds with the evolution of heat. An explosion is thus an extremely rapid decomposition, accompanied by the production of a large volume of gas and the development of much heat.

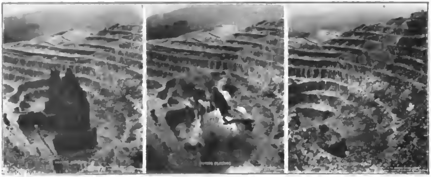

Fig. 1.—Blast at Lord Penrhyn's slate quarries.

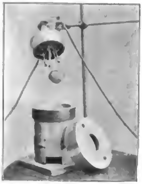

Fig. 2.—Berthelot calori-metric bomb.

There are two well-defined modes of explosion which can be described as combustion and detonation. In the former case, the explosive is simply ignited and combustion takes place by transference of heat from layer to layer of the explosive. The rapidity with which the combustion proceeds depends not only on the physical form of the explosive, but also on the pressure under which the decomposition takes place. When in the form of fine grains, combustion proceeds much more quickly than when the grains are large, and the powder maker takes advantage of this fact in preparing powder for rifles and the various sized large guns.

Detonation, on the other hand, has to be started by a sufficiently strong impulse, such as the explosion of a charge of mercury fulminate; it proceeds much more rapidly and is due to the formation of an explosion wave that has a velocity of thousands of meters a second.

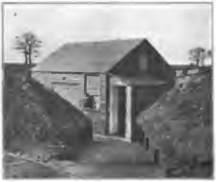

Fig. 4.—"Mounded" house, Cotton Powder Works.

Black gunpowder and allied explosives, as well as the smokeless powders, belong to the first or combustion class, and they are commonly designated "low" explosives.

"High" explosives indicate those, such as dynamites and nitrate of ammonia explosives, which detonate and have a greater shattering action than the former.

The volume and composition of the gas produced, both in regard to the power of the explosive, and, in the case of mining explosives, the health of the miner, are of great importance. These gases are largely determined by the original composition of the explosive.

When there is insufficient oxygen for complete oxidation, the products are carbon dioxide, carbon monoxide, hydrogen, water, and nitrogen, but the relative proportions vary with the pressure developed. When such an explosive is fired in a closed vessel under different densities of charge, that is, different quantities of explosive in the same volume, the volume and composition of the gas varies with the pressure developed by the explosion. The carbon dioxide and hydrogen increase and the carbon monoxide and water diminish as the pressure increases; also, at high pressures, considerable amounts of methane are formed. In the foregoing, it has been assumed that complete explosive decomposition has taken place.

When a high explosive burns, instead of explodes, the chemical changes are not only very much slower and the disruptive effect practically *nil*, but the character of the gases is entirely changed, large volumes of poisonous nitrous fumes along with other gases being produced.

The temperature developed by an explosive is of importance, because the higher the temperature the greater the erosion of the guns.

Nearly all blasting explosives, except black powder, are fired by means of a detonator. Fulminate of mercury is the most widely employed constituent of the detonator charge; sometimes it is used alone, but more usually with an admixture of 20 per cent of potassium chlorate.

Trinitrotoluene, picric acid, and tetranitromethylaniline, each with a small quantity of fulminate as primer, have also been used for charging detonators.

More recently lead azide prepared from the sodium salt of hydrazoic acid N_3H, by means of a lead salt, has also been used, as it has a greater power of initiating detonation, so that less azide is required to detonate an organic explosive than would be required of fulminate. Its manufacture, however, is more delicate than fulminate, and the formation of large crystals must be avoided, as they have the unpleasant property of sometimes exploding spontaneously.

Another new explosive body which appears likely to play an important part as a charge for detonators is tetranitroaniline, manufactured by nitrating metanitroaniline. It combines an exceptional explosive power with aromatic stability and has a high density.

It can be easily detonated, even when highly compressed, and has such a high percentage of oxygen that it can be detonated without residue or smoke.

In blasting operations, gunpowder and detonators are either fired by a time fuse or electrically. The time fuse consists of a thin but continuous core of black powder covered by a case of twine and tape and varnish. It is made to burn at a known uniform rate, generally 2 feet a minute, in order that a sufficient length can be used to allow the shot-firer, after lighting the fuse, to reach a place of shelter before the explosion takes place.

The instantaneous fuse, which burns at the rate of 100-300 feet a second, affords a means of firing many charges simultaneously.

Occasionally it happens that a coil is defective, generally through discontinuity in the powder core. C. Napier Hake, late Chief Inspector of Explosives for Victoria, ingeniously employed X-ray photography to examine suspected coils, and, in this way, was able to recognize those which were defective.

One of the most interesting recent productions is the "detonating fuse," a soft metal tube filled with trinitrotoluene which detonates with greater velocity than most explosives. When placed alongside the cartridges in a deep borehole, it is considered to give an enhanced blasting effect by causing the whole charge to go off more simultaneously than when the column of explosive is fired at one end by a detonator in the usual way.

With the object of preventing accidents so far as possible, and minimizing the loss of life should an explosion occur, a number of rules and regulations have been drawn up by the Explosives Department of the Home Office which have to be followed in the construction and working of explosive factories.

The object of the restrictions is to allow only limited quantities of explosive material and a limited number of work-people in one building at a time, and, further, to place the different buildings at such distances from each other, or surround them by protecting earth mounds, that in the event of an explosion the effect is localized as much as possible and the explosives in the adjacent buildings are not "set-off."

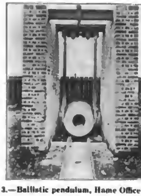

Fig. 3.—Ballistic pendulum, Home Office testing station.

The manufacture of guncotton and the other forms of nitrocellulose is carried out in the first stages in the non-danger part of the factory.

The most interesting development of the nitration process is the method devised by J. and W. Thomson, of the Royal Gunpowder Factory, Waltham Abbey.

The composition of the acid mixture is of the greatest importance and largely determines the character of the product. The ratio between the nitric and sulphuric acids and the water must be accurately adjusted.

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* From a course of lectures delivered before the Institute of Chemistry, at King's College, London, by Mr. William Macnab, and published by the Institute. Reproduced from *Nature*.

It must also be remembered that the cotton is by no means a definite chemical body, and its physical state plays an important part. Samples of different cottons, under the same conditions in a bath of the same composition, while yielding nitrocelluloses containing practically the same percentage of nitrogen, may vary in solubility in ether-alcohol from 25 per cent to 70 per cent.

Turning now to the production of nitroglycerine, this manufacture is much simpler than that of nitrocellulose; at the same time, it is much more dangerous.

The plant which is at present most employed is known as the nitrator-separator. It was developed at Waltham Abbey by Sir Frederic Nathan and W. Rintoul, and is a great advance on the former methods.

The nitrator-separator is a cylindrical leaden vessel with a coned top; inside are placed leaden coils, through which cooling water circulates, and pipes, through which compressed air is blown to mix the contents. The glycerine is introduced in the form of a fine spray under the acid by means of a special injector, worked also by compressed air.

When everything goes right, the nitration of the charge is usually completed in about one hour; the agitation with the air is discontinued and the separation of the nitroglycerine from the acids takes place—being lighter it comes to the top. A pipe, in which a glass window is fitted, leads from the top of the nitrator-separator to a pre-washing tank; by allowing waste acid from a previous operation to enter at the bottom, the nitroglycerine is forced over into the washing tank; and the flow of acid is stopped whenever all the nitroglycerine has passed into the washing tank, which can be observed through the window.

With the object of preventing explosions of gas or coal-dust in mines, our Government, in common with many others, has instituted a test which explosives have to pass before they are put on the "permitted" list, and are available for use in fiery or dusty mines. This test has varied in the different countries, and a change has been introduced recently, since the transference of the testing station from Woolwich to Rotherham. Much difference of opinion still exists as to the best means of carrying out such a test.

One of the chief factors in determining the ignition is the temperature developed by the gases of explosion. Owing to lack of data, the temperature cannot be calculated with sufficient accuracy, and other conditions obtain which make a practical test more helpful. Nevertheless, the temperature is of great importance and many means are employed of lowering it, such as adding salts which absorb heat on volatilization.

The rapidity of detonation, the length of the flame, and the heat evolved, all influence the readiness with which explosives ignite gas or coal-dust; but in this connection knowledge and progress have been chiefly promoted by direct experiment at the various testing stations here and abroad.

The filling material for shells has been the subject of much experiment and trial by the different countries. Picric acid, under the various names of melinite, lyddite, shimose powder, etc., has been extensively tried and found wanting. Ammonal, containing ammonium nitrate, with a large percentage of trinitrotoluol and finely divided aluminium, is a very safe and powerful explosive, and has been adopted as the charge for shells by the Austrian government. It has the disadvantage of containing the hygroscopic ammonium nitrate as an ingredient, and must consequently be specially protected against moisture. At present, trinitrotoluol is the body which has commended itself to most of the governments as the best bursting charge for shells, torpedoes, and general military blasting work, and has just been adopted by our own government.

Experience in America, South Africa, and Australia has shown that the fruit-grower has a real friend in explosives, and it seems to me that, in this country also, we must wake up to this beneficent aspect of explosives and the means they offer of attaining results otherwise impossible.

In the case of tree planting, it is not the mere comparison of the cost of the excavation of the hole in which to place the tree which has to be considered. When an explosive is employed, the soil is shaken up and fissured for a comparatively wide area beyond the hole actually required for the tree. When, as often happens, there is a hard and impervious subsoil beyond reach of the spade, this is also opened and fissured, and experience has shown that trees planted in ground prepared by explosives make a much more vigorous and rapid growth than when planted in the ordinary way. Some trees have begun bearing after four years, while others similarly situated but spade planted did not yield fruit until six years, certainly a good return for the investment.

In the case of existing orchards little can be done in the ordinary way to aerate or render the soil more pervious to the roots and moisture, but a small cartridge inserted at some depth below the tree, or a larger one exploded at a depth of 3 feet or so below the surface and midway between trees planted about 15 feet apart, has a most beneficial effect in loosening the soil without injuring the trees. The roots have less resistance to overcome, the soil is aerated, the moisture retaining properties improved, and a new lease of life is thus given to an old orchard; the trees become more vigorous and productive, and indeed are rejuvenated.

Death of the Last of the Wild Pigeons

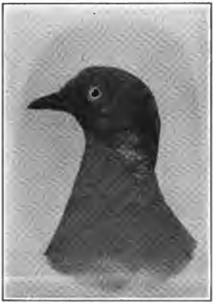
By R. W. Shufeldt, M. D.

MANY years ago, the Cincinnati Zoological Company was so fortunate as to have no fewer than eight living specimens of the Passenger Pigeon (*Ectopistes migratorius*) in its gardens. From time to time these died, and were doubtless disposed of in one way or another until, finally, there remained of the little flock only a single female bird. As they passed away, the same species was being rapidly exterminated in nature, until one day it became evident to everyone who knew anything of such matters that the wild pigeon had become extinct. Man had eliminated it from the face of the earth. Rewards were then offered for specimens, and these became more substantial, as the fact was clearly appreciated that the "blue pigeons" were among the things of the past. Finally, a thousand dollars were held out as an inducement to any person who could locate a nest with a fresh clutch (2) of eggs in it, and furnish that information to the party offering the reward. This brought many "finds" in; but they all proved to be either mourning doves or band-tailed pigeons, and at last it became very evident that not a single Passenger Pigeon was left at large in the country, where formerly they migrated in flocks of billions.

Meanwhile the sole survivor, the female in the Cincinnati "Zoo," lived on, until the term of its captivity was an unusually long one for any wild bird deprived of its liberty, outside of certain species, such as the parrots and others. But the end was sure to come; and at last, after it had survived for twenty-nine long years it succumbed to what was, apparently, nothing more than advanced age. This occurred at 1 o'clock in the morning on September 1st, 1914, and the body, as had been previously arranged, was sent to the Smithsonian Institution in Washington, in that science might make the best possible use of it. It fell to me to take part in this, and through the courtesy of C. W. Richmond, assistant curator of birds of that institution, I arrived at the room in the National Museum about one hour after the arrival of the specimen (September 4th, 1914).

At my request, it was first taken to the photographic gallery, where I posed it in the three conventional aspects (anterior, posterior, and lateral) for the purpose of taking its picture, and that number of 8 by 10 negatives were successfully made. From there, it was at once taken to my home, 2356 Eighteenth Street, Washington, D. C., by Mr. William Palmer of the Smithsonian Institution, who had been delegated to skin it for the taxidermist, who was absent from the city at the time of the arrival of the specimen. While Mr. Palmer was thus engaged in one of my work-rooms, I was in my dark-room, developing several negatives which I had previously made of the bird with my own camera (5 by 8), namely, two of its head, natural size, and one of the torso, before the skin had been completely removed.

Before Mr. Palmer took his leave, he carried out Dr. Richmond's directions, and turned over to me the body of the bird, for anatomical dissection and description. This latter labor, including the making of other negatives and a colored plate, has all been completed, and early next year my report thereon will be duly published in another connection.



Side view of the head of the last Passenger Pigeon.

The side view of the head, which illustrates the present brief article, is a reproduction of one of my own photographs of the specimen—one of those taken at my home, as mentioned above. It is natural size, and I restored the eye in that the portrait might have a more life-like appearance. When Mr. Nelson R. Wood, the veteran taxidermist of the Smithsonian Institution, returns to duty, the specimen will be duly mounted for the Ornithological Exhibition Rooms of the National Museum, where it will be sure to attract very considerable interest on the part of the visiting public.

It is to be hoped that it may, in time, have some little influence in staying the hand of man in his career of extermination of such incomparably beautiful creatures in nature. I, for one, greatly fear that this will not be the case. In due course, the day will come when practically all of the world's avifauna will have become utterly extinct. Such a fate for it is coming to pass now, with far greater rapidity than most people realize.

Tsing-Tau, Germany's Eastern Colony

NOT much accurate information exists as to the ability of Germany's naval base in the Far East to resist a vigorous attack from the sea, but the position is one of great natural strength and importance. The Bay of Kiao-Chau, on the northeast shore of which it stands, together with the surrounding district, was seized by Germany in November, 1897. Early in that month two German missionaries were attacked and killed while traveling in the Province of Shantung, and a few days later the Kaiser's Pacific squadron anchored in the estuary, an ultimatum being sent to the Chinese general to leave with his troops within three hours. He did so under protest; the German flag was hoisted, and after negotiations with Pekin the matter was settled in March, 1898, by the leasing of the bay and territory to the Emperor for ninety-nine years.

The district thus acquired by force amounted to some 200 square miles, and with its land-locked harbor has been described as the key to Northern China, Lord Charles Beresford being among those who have expressed the opinion that it represents one of the most important naval bases on the Chinese coast.

Facing the Yellow Sea, about 250 miles in a direct line southeast of Pekin, and almost opposite the southern extremity of Korea, the bay of Kiao-Chau is less than two miles wide at its entrance. Within it extends over an area of something like 150 square miles of deep water affording at all times a safe anchorage for ships of any size. The inlet is entirely surrounded by hills from 400 feet to 600 feet high, most of them offering admirable sites for fortifications. If the defensive works planned when the place was seized have been carried out and fully armed, the harbor must present formidable obstacles to a sea attack, while the land approaches are guarded by a series of fortifications across the head of the peninsula. The garrison consists of 5,000 German marines and a small force of Chinese soldiers, the remainder of the white population being very inconsiderable.

The immediately surrounding district is rich in mineral and metalliferous deposits, a large but undeveloped supply of coal being one of the inducements which led the Germans to fix on Kiao-Chau for settlement. Other local industries are connected with fruits and vegetables, silk culture, brewing, and soapmaking. Two years ago the imports amounted in value to 114,838,000 marks, and the exports to 80,265,000 marks. In the winter months the harbor is the natural outlet for the trade of Northern China, a railway, 272 miles long, from Tsing-Tau to Poshan, having much increased its value in this direction. The German war vessels in Chinese waters, as well as a large number of German trading ships are probably sheltering under the Tsing-Tau heights at the present moment.—*The Daily Telegraph, London.*

Cosmical Physics*

The Effect of the Law of Gravitation Applied to the Moon

By Prof. E. W. Brown, F.R.S.

When a comparison between the work of the lunar theorist and that of the observer has to be made, it is necessary to take into consideration the facts and results obtained by astronomers for purposes not directly connected with the moon: the motions of the earth and planets, the position of the observer, the accuracy of star catalogues, the errors of the instruments used for the measurement of the places of celestial objects, the personality of the observers—all these have to be considered; in fact, almost every one of the departments of the astronomy of position must be drawn upon to furnish necessary data. The time has now arrived when it may perhaps be possible to repay in some measure the debt thus contracted by furnishing to the astronomer, and perhaps also to the student of geodesy, and, if I may coin a word, of selenodesy, some results which can be deduced more accurately from a study of the moon's motion than in any other way. A long-continued exploration with few companions which ultimately leads to territories where other workers have already blazed paths gives the impression of having emerged from the thick jungle into open country. The explorer can once more join forces with his brother astronomers. He can judge his own results more justly, and have them judged by others.

If, then, an excuse be needed for overstepping the limits which seem, by silent consent, to have been imposed on those who devote themselves to lunar problems, it consists in a desire to show that these limits are not necessary, and that a study of the motion of the moon can be of value and can contribute its share to the common funds of astronomy. The history of the motion of the moon has been for more than two centuries a struggle between the theorists and the observers. Ever since the publication of the "Principia" and the enunciation of the law of gravitation by Isaac Newton, a constant effort has been maintained to prove that the moon, like the other bodies of the Solar System, obeyed this law to its farthest consequences. While the theory was being advanced, the observers were continually improving their instruments and their methods of observing, with the additional advantage that their efforts had a cumulative effect; the longer the time covered by their observations, the more exact was the knowledge obtained. The theorist lacked the latter advantage: if he started anew he could only use the better instruments for analysis provided by the mathematician. He was always trying to forge a plate of armor which the observer, with a gun whose power was increasing with the time, could not penetrate. In the struggle, the victory rarely failed to rest with the observer. Within the last decade we theorists have made another attempt to forge a new plate out of the old materials; whether we have substantially gained the victory must rest partly on the evidence I have to place before you to-day, and partly on what the observer can produce in the near future. There are three well-defined periods in the history of the subject as far as a complete development of the moon's motion is concerned.

From the publication of the "Principia," in 1687, when Newton laid down the broad outlines, until the middle of the eighteenth century, but little progress was made. It seems to have required over half a century for analysis by symbols to advance sufficiently far for extensive applications to the problems of celestial mechanics. Clairaut and d'Alembert both succeeded in rescuing the problem from the geometrical form into which Newton had cast it, and in reducing it to analysis by the methods of the calculus. They were followed by Leonard Euler, who, in my opinion, is the greatest of all the successors of Isaac Newton as a lunar theorist. He initiated practically every method which has been used since his time, and his criticisms show that he had a good insight into their relative advantages. A long roll of names follows in this period. It was closed by the publication of the theories of Delaunay and Hansen, and the tables of the latter, shortly after the middle of the nineteenth century. From then to the end of the century, the published memoirs deal with special parts of the theory, or with its more general aspects, but no complete development appeared which could supersede the results of Hansen. My own theory, which was completed a few years ago, is rather the fulfillment to the utmost of the ideas of others than a new mode of finding the moon's motion. Its object was severely practical—to find in the most accurate way and by the shortest path the complete effect of the law of gravitation applied to the moon. It is a development of Hill's classic memoir of 1877. Hill in his turn was indebted to some extent to Euler. His indebtedness would have been greater had he been aware of a little-known paper of the latter, "Sur la Variation de la Lune," in which the orbit, now called the variation orbit, is obtained, and its advantages set forth in the words: "Quelque chimérique cette question j'ose assurer que, si l'on réussissoit à en trouver une solution parfaite on ne trouveroit presque plus de difficulté pour déterminer le vrai mouvement de la Lune réelle. Cette question est donc de la dernière importance, et il sera toujours bon d'en approfondir toutes les difficultés, avant qu'on en puisse espérer une solution complète." In the final results of my work, the development aims to include the gravitational action of every particle of matter which can have a sensible effect on the moon's motion, so that any difference which appears between theory and observation may not be set down to want of accuracy in the completeness with which the theory is carried out. Every known force capable of calculation is included. So much for the theory. Gravitation, however, is only a law of force: we need the initial position, speed, and direction of motion.

To get this with sufficient accuracy no single set of observations will serve; the new theory must be compared with as great a number of these as possible. To do this directly from theory is far too long a task, and, moreover, it is not necessary. In the past, every observation has been compared with the place shown in the Nautical Almanac, and the small differences between them have been recorded from day to day. By taking many of these differences and reducing them so as to correspond with differences at one date, the position of the moon at that date can be found with far greater accuracy than could be obtained through any one observation. At the Greenwich Observatory, the moon has been observed and recorded regularly since 1750. With some 120 observations a year, there are about 20,000 available for comparison, quite apart from shorter series at other observatories. Unfortunately, these observations are compared with incorrect theories, and, in the early days, the observers were not able to find out, with the accuracy required to-day, the errors of their instruments or the places of the stars with which the moon was compared. But we have means of correcting the observations, so that they can be freed from many of the errors present in the results which were published at the time the observations were made. We can also correct the older theories. They can be compared with the new theory and the differences calculated: these differences need not ever be applied to the separate observations, but only to the observations combined into properly chosen groups. Thus the labor involved in making use of the earlier observations is much less than might appear at first sight. For the past eighteen months, I have been engaged in this work of finding the differences between the old theories and my own, as well as in correcting those observations which were made at times before the resources of the astronomer had reached their present stage of perfection. I have not dealt with the observations from the start. Other workers—notably Airy in the last century, and Cowell in this—have done the greater part of the labor. My share was mainly to carry theirs a stage further by adopting the latest theory and the best modern practice for the reduction of the observations. In this way, a much closer agreement between theory and observation has been obtained, and the initial position and velocity of the moon at a given date are now known with an accuracy comparable with that of the theory. I shall shortly return to this problem and exhibit this degree of accuracy by means of some diagrams which will be thrown on the screen.

I have spoken of the determination of these initial values as if it constituted a problem separate from the theory. Theoretically it is so, but practically the two must go together. The increase in accuracy of the theory has gone on successively with increase in accuracy of the determination of these constants. We do not find, with a new theory, the new constants from the start, but corrections to the previously adopted values of these constants. In fact, all the problems of which I am talking are so much interrelated that it is only justifiable to separate them for the purposes of exposition. Let us suppose that the theory and these constants have been found in numerical form, so that the position of the moon is shown by means of expressions which contain nothing unknown but the time. To find the moon's place at any date, we have then only to insert that date and to perform the necessary numerical calculations. This is not done directly, on account of the labor involved. What are known as "Tables of the Moon's Motion" are formed.

These tables constitute an intermediate step between the theory and the positions of the moon which are printed in the Nautical Almanac. Their sole use and necessity is the abbreviation of the work of calculation required to predict the moon's place from the theoretical values which have been found. For this reason, the problem of producing efficient tables is not properly scientific: it is mainly economic. Nevertheless, I have found it as interesting and absorbing as any problem which involves masses of calculation is to those who are naturally fond of dealing with arithmetical work. My chief assistant, Mr. H. B. Hedrick, has employed his valuable experience in helping me to devise new ways of arranging the tables and making them simple for use. A table is mainly a device by which calculations which are continually recurring are performed once for all time, so that those who need to make such calculations can read off the results from the table.

In the case of the moon, the tables go in pairs. Each term in the moon's motion depends on an angle, and this angle depends on the date. One table gives the value of the angle at any date (a very little calculation enables the computer to find this), and the second table gives the value of the term for that angle. As the same angles are continually recurring, the second table will serve for all time. We can, however, do better than construct one table for each term. The same angle can be made to serve for several terms, and consequently one table may be constructed so as to include all of them. In other words, instead of looking out five numbers for five separate terms, the computer looks out one number which gives him the sum of the five terms. The more terms we can put into a single table, the less work for the astronomer who wants the place of the moon, and therefore the more efficient the tables. A still better device is a single table which depends on two angles, known as a double-entry table; many more terms can usually be included in this than in a single-entry table. The double interpolation on each such table is avoided by having one angle the same for many double-entry tables, and interpolating for that angle on the sum of the numbers extracted from the tables. The problem of fitting the terms into the smallest number of tables is a problem in combinations—something like a mixture of a game at chess and a picture puzzle, but unlike the latter in the fact that the intention is to produce ease and simplicity instead of difficulty. This work of arrangement is now completed, and, in fact, about five sixths of the calculations necessary to form the tables are done. Over one third of the copy is ready for the printer; but, owing to the large mass of the matter, it will take from two to three years to put it through the press. The cost of performing the calculations and printing the work has been met from a fund specially set aside for the purpose by Yale University. A few statistics will, perhaps, give an idea of our work. Hansen has 300 terms in his three co-ordinates, and these are so grouped that about a hundred tables are used in finding a complete place of the moon. We have included over 1,000 terms in about 120 tables, so that there are, on the average, about eight terms per table. (In one of our tables we have been able to include no less than forty terms.) Each table is made as extensive as possible, in order that the interpolations—the bane of all calculations—shall be easy. The great majority of them involve multiplications by numbers less than 100. There are less than ten tables which will involve multiplications by numbers between 100 and 1,000, and none greater than the latter number. The computer who is set to work to find the longitude, latitude, and parallax of the moon will not need a table of logarithms from the beginning to the end of his work. The reason for this is that all multiplications by three figures or less can be done by Crelle's well-known tables or by a computing machine. But Mr. Hedrick has devised a table for interpolation to three places which is more rapid and easy than either of these aids. It is, of course, of use generally for all such calculations, and arrangements are now being made for the preparation and publication of his tables.

The actual work of finding the place of the moon from the new lunar tables will, I believe, not take more time—perhaps less—than from Hansen's tables, as soon as the computer has made himself familiar with them. Fortunately for him, it is not necessary to understand the details of their construction: he need only know the rules for using them. I am now going to show, by means of some diagrams, the deviations of the moon from its theoretical orbit, in which, of course, errors of observation are included. The first two slides exhibit the average deviation of the moon from its computed place for the past century and a half in longitude. The averages are taken over periods of 114 days, and each point of the continuous line shows one such average. The dots are the results obtained by Newcomb from occultations; the averages for the first century are taken over periods of several years, and in the last sixty years over every year.

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*At the Australian meeting of the British Association.

In both cases the same theory and the same values of the constants have been used. Only one empirical term has been take out—the long-period fluctuation found by Newcomb having a period of 270 years, and a coefficient of 13 sec. I shall show the deviations with this term included in a moment. The first point to which attention should be drawn is the agreement of the results deduced from the Greenwich meridian observations and those deduced from occultations gathered from observatories all over the world. There can be no doubt that the fluctuations are real, and not due to errors of observation. A considerable difference appears about 1820, for which I have not been able to account; but I have reasons for thinking that the difference is mainly due to errors in the occultations rather than in the meridian values. In the last sixty years the differences become comparatively small, and the character of the deviation of the moon from its theoretical orbit is well marked. This deviation is obviously of a periodic character; but attempts to analyze it into one or two periodic terms have not met with success.

The number of terms required for the purpose is too great to allow one to feel that they have a real existence, and that they would combine to represent the motion in the future. The straight-line character of the deviations is a rather marked peculiarity of the curves. The actual deviations on a smaller scale are shown in the next slide. The great empirical term has here been restored, and is shown by a broken line. The continuous line represents the Greenwich meridian observations; the dots are Newcomb's results from the occultations before 1750, the date at which the meridian observations begin. With a very slight amount of smoothing, especially since 1850, this diagram may be considered to show the actual deviations of the moon from its theoretical orbit. The next slide shows the average values of the eccentricity and of the position of the perigee. The deviations are those from the values which I have obtained. It is obvious at once that there is little or nothing systematic about them; they may be put down almost entirely to errors of observation. The diminishing magnitude of the deviations as time goes on is good evidence for this; the accuracy of the observations has steadily increased.

The coefficient of the term on which the eccentricity depends is found with a probable error of 0.02 sec., and the portion from 1750 to 1850 gives a value for it which agrees with that deduced from the portion 1850 to 1901 within 0.01 sec. The eccentricity is the constant which is now known with the highest degree of accuracy of any of those in the moon's motion. For the perigee there was a difference from the theoretical motion which would have caused the horizontal average in the curve to be tilted up one end over 2 sec. above that at the other end. I have taken this out, ascribing it to a wrong value for the earth's ellipticity; the point will be again referred to later. The actual value obtained from the observations themselves has been used in the diagram, so that the deviations shown are deviations from the observed value. The next slide shows the deviations of the mean inclination and the motion of the node, as well as of the mean latitude from the values deduced from the observations. In these cases the observations only run from 1847 to 1901. It did not seem worth while to extend them back to 1750, for it is evident that the errors are mainly accidental, and the mean results agreed so closely with those obtained by Newcomb from occultations that little would have been gained by the use of the much less accurate observations made before 1847.

The theoretical motion of the node differs from its observed value by a quantity which would have tilted up one end of the zero line about 0.5 sec. above the other; the hypothesis adopted in the case of the perigee will account for the difference. The mean latitude curve is interesting. It should represent the mean deviations of the moon's center from the Ecliptic; but it actually represents the deviations from a plane 0.5 sec. below the Ecliptic. A similar deviation was found by Newcomb. Certain periodic terms have also been taken out. The explanation of these terms will be referred to directly. The net result of this work is a determination of the constants of eccentricity, inclination, and of the positions of the perigee and node with practical certainty. The motions of the perigee and node here agree with their theoretical values when the new value of the earth's ellipticity is used. The only outstanding parts requiring explanation are the deviations in the mean longitude.

If inquiry is made as to the degree of accuracy which the usual statement of the gravitation law involves, it may be said that the index which the inverse-square law contains does not differ from 2 by a fraction greater than 1/400,000,000. This is deduced from the agreement between the observed and theoretical motions of the perigee when we attribute the mean of the differences found for this motion and for that of the node to a defective value of the ellipticity of the earth. I have mentioned the mean deviation of the latitude of the moon from the Ecliptic. There are also periodic terms with the mean longitude as argument occurring both in the latitude and the longitude. My explanation of these was anticipated by Prof. Bakhuysen by a few weeks.

The term in longitude had been found from two series of Greenwich observations, one of 28 and the other of 21 years, by van Steenwijk, and Prof. Bakhuysen, putting this with the deviations of the mean latitude found by Hansen and himself, attributed them to systematic irregularities of the moon's limbs. What I have done is to find (1) the deviation of the mean latitude for 64 years, (2) a periodic term in latitude from observations covering 55 years, and (3) a periodic term in longitude from observations covering 150 years, the period being that of the mean longitude.

Further, if to these be added Newcomb's deviations of the mean latitude derived (a) from immersions and (b) from immersions, we have a series of five separate determinations—separate because the occultations are derived from parts of the limb not wholly the same as those used in meridian observations. Now all these give a consistent shape to the moon's limb referred to its center of mass. This shape agrees qualitatively with that which may be deduced from Franz's figure. I throw on the screen two diagrammatic representations of these irregularities obtained by Dr. F. Hayn from a long series of actual measures of the heights and depths of the lunar formations. The next slide shows the systematic character more clearly. It is from a paper by Franz. It does not show the character of the heights and depths at the limb, but we may judge of these from the general character of the high and low areas of the portions which have been measured, and which extend near to the limbs. I think there can be little doubt that this explanation of these small terms is correct, and if so, it supplies a satisfactory cause for a number of puzzling inequalities.

The most interesting feature of this result is the general shape of the moon's limb relative to the center of mass and its relation to the principle of isostasy. Here we see with some definiteness that the edge of the southern limb in general is further from the moon's center of mass than the northern. Hence we must conclude that the density at least of the crust of the former is less than that of the latter, in accordance with the principle mentioned. The analogy to the figure of the earth with its marked land and sea hemispheres is perhaps worth pointing out, but the higher ground in the moon is mainly on the south of its Equator, while that on the earth is north.

Unfortunately, we know nothing about the other face of the moon. Nevertheless, it seems worth while to direct the attention of geologists to facts which may ultimately have some cosmogonic applications. The astronomical difficulties are immediate: different corrections for meridian observations in latitude, in longitude, on Mösting A, for occultations and for the photographic method, will be required. I next turn to a question, the chief interest of which is geodetic rather than astronomical. I have mentioned that a certain value of the earth's ellipticity will make the observed motions of the perigee and node agree with their theoretical values. This value is 1/293.7 ± 0.3. Now Helmert's value obtained from gravity determinations is 1/298.3. The conference of Nautical Almanac Directors in 1911 adopted 1/1,297. There is thus a considerable discrepancy. Other evidence, however, can be brought forward.

Not long ago a series of simultaneous observations at the Cape and Greenwich Observatories was made in order to obtain a new value of the moon's parallax. After five years' work a hundred simultaneous pairs were obtained, the discussion of which give evidence of their excellence. Mr. Crommelin, of the Greenwich Observatory, who undertook the discussion, determined the ellipticity of the earth by a comparison between the theoretical and observed values of the parallax. He found an ellipticity 1/294.4 ± 1.5 closely agreeing with that which I have obtained. Finally, Col. Clarke's value obtained from geodetic measures was 1/293.5. We have thus three quite different determinations ranging round 1/294 to set against a fourth determination of 1/298. The term in the latitude of the moon which has often been used for this purpose is of little value on account of the coefficient being also dependent on the value of the obliquity of the Ecliptic; such evidence as it presents is rather in favor of the larger value.

I omit Hill's value, obtained from gravity determinations, because it is obviously too large. Here, then is a definite issue. To satisfy the observations of the moon in at least three different parts, a value near 1/294 must be used; while the value most carefully found from gravity determinations is 1/298. As far as astronomy is concerned, the moon is the only body for which a correct value of this constant is important, and it would seem inadvisable to use a value which will cause a disagreement between theory and observation in at least three different ways. It is a question whether the conference value should not be changed with the advent of the new lunar tables.

In looking forward to future determinations of this constant, it seems to be quite possible that direct observations of the moon's parallax are likely to furnish at least as accurate a value of the earth's shape as any other method. This can be done, I believe, much better by the Harvard photographic method than by meridian observations. Two identical instruments are advisable for the best results—one placed in the Northern and the other in the Southern Hemisphere, from 60 deg. to 90 deg. apart in latitude, and as nearly as possible on the same meridian. On nights which are fine at both stations, from fifteen to twenty pairs of plates could be obtained. In a few months it is possible that some 400 pairs might be obtained. These should furnish a value for the parallax with a probable error of about 0.02 sec. and a value for the ellipticity within half a unit of the denominator 294.

It would be still more interesting if the two instruments could be set up on meridians in different parts of the earth. The Cape and a Northern observatory—Upsala, for example—would furnish one arc; Harvard and Ariquipa or Santiago another. If it were possible to connect by triangulation Australia with the Asiatic continent, a third could be obtained near the meridian of Brisbane; or, accepting the observed parallax and the earth's ellipticity, we could find by observation the lengths of long arcs on the earth's surface with high accuracy. In any case, I believe that the time must shortly come when the photographic method of finding the moon's place should be taken up more extensively, whether it be used for the determination of the moon's parallax and the earth's ellipticity or not.

The Greenwich meridian observations have been, and continue to be, a wonderful storehouse for long series of observations of the positions of the sun, moon, planets, and stars. In the United States, Harvard Observatory has adopted the plan of securing continuous photographic records of the sky with particular reference to photometric work. Under Prof. Pickering it will also continue the photographic record of the moon's position as long as arrangements can be made to measure the plates and compute the moon's position from them. In spite of the fact that Harvard Observatory has undertaken to continue for the present the work of photographing the moon's position, I believe that this method should find a permanent home in a national observatory. It has already shown itself capable of producing the accuracy which the best modern observations of Greenwich can furnish, and no higher praise need be given. If this home could be found in the Southern Hemisphere, and more particularly in Australia, other advantages would accrue. But we should look for more than this.

In an observatory whose first duty might be the securing of the best daily records of the sky, the positions of the sun, stars, planets, a couple of plates of the moon on every night when she is visible would be a small matter. What is needed is an organization so constructed as to be out of the reach of changing governmental policy, with a permanent appropriation and a staff of the highest character removed from all political influences. It could render immense service to astronomers, not only in the Empire, but all over the world.

I have shown you what the outstanding residuals in the moon's motion are: they consist mainly of long-period fluctuations in the mean longitude. I have not mentioned the secular changes, because the evidence for them does not rest on modern observations, but on ancient eclipses, and these are matters too debatable to discuss in the limited time allotted to me for this address. It may be said, however, that the only secular motion which is capable of being determined from the modern observations, and is not affected by the discussion of ancient eclipses—namely, the secular motion of the perigee—agrees with its theoretical value well within the probable error. With this remark, I pass to the empirical terms.

These unexplained differences between theory and observation may be separated into two parts. First, Newcomb's term of period between 250 and 300 years, and coefficient 13 sec.; and, second, the fluctuations, which appear to have an approximate period of 60 to 70 years. The former appears to be more important than the latter; but from the investigator's point of view it is less so. The force depends on the degree of inclination of the curve to the zero line or on the curvature, according to the hypothesis made. In either case, the shorter-period term is much more striking, and, as I have pointed out on several occasions, it is much more likely to lead to the sources of these terms than the longer period. It is also, at least for the last sixty years, much better determined from observation, and is not likely to be confounded with unknown secular changes. Various hypotheses have been advanced within the last few years to account for these terms. Some of them postulate matter not directly observed, or matter with unknown constants; others, deviations of the Newtonian law from its exact expression; still others, non-gravitational forces. M. St. Blancat examines a variety of cases of intra-Mercurial planets, and arrives at the conclusion that such matter, if it exists, must have a mass comparable with that of Mercury. Some time ago, I examined the same hypothesis, and arrived at similar results.

The smallest planet with density four times that of water, which would produce the long inequality, must have a disk of nearly 2 sec. in its transit across the sun, and a still larger planet would be necessary to produce the shorter-period terms. But observational attempts, particularly those made by Perrine and Campbell, have always failed to detect any such planet, and Prof. Campbell is of the opinion that a body with so large a disk could hardly have been overlooked. If we fall back on a swarm instead of a single body, we replace one difficulty by two. The light from such a swarm would be greater than that from a single body, and would therefore make detection more likely. If the swarm were more diffused, we encounter the difficulty that it would not be held together by its own attraction, and would therefore soon scatter into a ring. Such a ring cannot give periodic changes of the kind required. The shading of gravitation by interposing matter—e. g., at the time of eclipses—has been examined by Bottlinger. For one reason alone, I believe this is very doubtful. It is difficult to see how new periodicities can be produced. The periods should be combinations of those already present in the moon's motion. The sixty to seventy years' fluctuation stands out in this respect because its period is not anywhere near any period present in the moon's motion, or any probable combination of the moon's periods. Indeed, Dr. Bottlinger's curve shows this: there is no trace of the fluctuation.

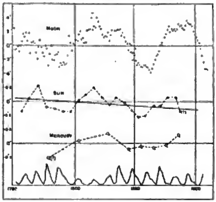
Some four years ago, I examined a number of hypotheses. The motions of the magnetic field of the earth and of postulated fields on the moon had to be rejected, mainly because they caused impossible increases in the mean motion of the perigee. An Equatorial ellipticity of the sun's mass, combined with a rotation period very nearly one month in length, appeared to be the best of these hypotheses. The obvious objections to it are, first, that such an ellipticity, small as it can be (about 1/20,000), is difficult to understand on physical grounds, and, second, that the rotation period of the nucleus which might be supposed to possess this elliptic shape in the sun's Equator is a quantity which is so doubtful that it furnishes no help from observation, although the observed periods are well within the required limits. Dr. Hale's discovery of the magnetic field of the sun is of interest in this connection. Such a field, of non-uniform strength, and rotating with the sun, is mathematically exactly equivalent to an Equatorial ellipticity of the sun's mass, so that the hypothesis might stand from the mathematical point of view, the expression of the symbols in words being alone different.

The last published hypothesis is that of Prof. Turner who assumes that the Leonids have finite mass, and that a big swarm of them periodically disturbs the moon as the orbits of the earth and the swarm intersect. I had examined this myself last summer, but rejected it because, although it explained the straight-line appearance of the curve of fluctuations, one of the most important of the changes of direction in this curve was not accounted for. We have the further difficulty that continual encounters with the earth will spread the swarm along its orbit, so that the swarm with this idea should be a late arrival, and its periodic effect on the moon's motion of diminishing amplitude. With respect to the latter, the observed amplitude seems rather to have increased.

The main objection to all these ideas consists in the fact that they stand alone: there is as yet little or no collateral evidence from other sources. The difficulty, in fact, is not that of finding a hypothesis to fit the facts, but of selecting one out of many. The last hypothesis which I shall mention is one which is less definite than the others, but which does appear to have some evidence in its favor. The magnetic forces mentioned above were changes in the directions of assumed magnetic fields. If we assume changes in the intensities of the fields themselves, we avoid the difficulties of altering portions of the moon's motion other than that of the mean motion. We know that the earth's magnetic field varies, and that the sun has such a field, and there is no inherent improbability in attributing similar fields to the moon and the planets. If we assume that variations in the strength of these fields arise in the sun and are communicated to the other bodies of the Solar System, we should expect fluctuations having the same period and of the same or opposite phase, but differing in magnitude.

It therefore becomes of interest to search for fluctuations in the motions of the planets similar to that found in the moon's orbit. The material in available form for this purpose is rather scanty; it needs to be a long series of observations reduced on a uniform plan. The best I know is in Newcomb's "Astronomical Constants." He gives there the material for the earth arranged in groups of a few years at a time. The results for Mercury, given for another purpose, can also be extracted from the same place. For Venus and Mars, Newcomb unfortunately only printed the normal equations, from which he deduces the constants of the orbit. On the screen is shown a slide (see map) which exhibits the results for the Earth and Mercury compared with those for the moon. In the uppermost curve are reproduced the minor fluctuations of the moon shown earlier; the second curve contains those of the earth's longitude; the third, those of Mercury's longitude. [By accident, the mean motion correction has been left in the earth curve; the zero line is therefore inclined instead of being horizontal.] It will be noticed that the scales are different, and that the earth curve is reversed. In spite of the fact that the probable errors of the results in the second and third curves are not much less than their divergences from a straight line, I think that the correlation exhibited is of some significance. If it is, we have here a force whose period, if period in the strict sense it has, is the same as that of the effect. The latter is not, then, a resonance from combination with another period. We must, therefore, look for some kind of a surge spreading through the Solar System, and affecting planets and satellites the same way, but to different degrees. The lowest curve is an old friend—that of Wolf's sunspot-frequency—put there, not for that reason, but because the known connection for the last sixty years between sunspot-frequency and prevalence of magnetic disturbance enables us with fair probability to extend the latter back to 1750. With some change of phase, the periods of high and low maxima correspond nearly with the fluctuations above.

The eleven-year oscillation is naturally eliminated from the group results for the Earth and Mercury. One might expect it to be present in the lunar curve; but, owing to its shorter period, we should probably not obtain a coefficient of over half a second. Notwithstanding this fact, it is a valid objection to the hypothesis that there is no evidence of it in the moon's motion. Reasons may exist for this; but until the mechanism of the action can be made more definite, it is hardly worth while to belabor the point. The hypothesis presents many difficulties. Even if one is disposed to admit provisionally a correlation between the four curves—and this is open to considerable doubt—it is difficult to understand how, under the electron theory of magnetic storms, the motions of moon and planets can be sensibly affected.



I am perhaps catching at straws in attempting to relate two such different phenomena with one another; but when we are in the presence of anomalies which show points of resemblance, and which lack the property of analysis into strict periodic sequences, some latitude may be permissible.

In conclusion, what, it may well be asked, is the future of the lunar theory now that the gravitational effects appear to have been considered in such detail that further numerical work in the theory is not likely to advance our knowledge very materially? What good purpose is to be served by continuous observation of the moon and comparison with the theory? I believe that the answer lies mainly in the investigation of the fluctuations already mentioned. I have not referred to other periodic terms which have been found, because the observational evidence for their real existence rests on foundations much less secure. These need to be examined more carefully, and this examination must, I think, depend mainly on future observations rather than on the records of the past. Only by the greatest care in making the observations, and in eliminating systematic and other errors from them, can these matters be fully elucidated. If this can be achieved, and if the new theory and tables serve, as they should, to eliminate all the known effects of gravitation, we shall be in a position to investigate with some confidence the other forces which seem to be at work in the Solar System, and at which we can now only guess.

Assistance should be afforded by observations of the sun and planets, but the moon is nearest to us and is, chiefly on that account, the best instrument for their detection. Doubtless other investigations will arise in the future. But the solution of the known problems is still to be sought, and the laying of the coping-stone on the edifice reared through the last two centuries cannot be a simple matter.

The Sale of Mineral Waters in the United States

In a report issued by the United States Geological Survey some interesting facts are given in relation to the production of mineral waters in the United States, from which it appears that the sale of such waters reached the maximum of 64,674,486 gallons in 1908, since which time the reports show the business had decreased in 1913 to 57,807,000 gallons, in spite of the fact that the field of the statistics has been extended and reports have been received from an increasing number of operators. Not only has this change taken place, but there is also a tendency toward a lower price, which may be attributed to decreased sales of high-priced waters and increased sales of low-priced waters. The general tendency toward a decline in price is doubtless due to demand for good pure potable bottled waters at moderate cost in place of the former demand for waters reputed to possess exceptional curative properties. Detailed examination of the statistics for the last few years shows that the installation of municipal purification plants in several large cities has been followed by marked decrease in the sales of spring waters in the immediate vicinity, and doubtless general improvements in the quality of public water supplies in smaller municipalities throughout the country has similarly affected the mineral-water business and has contributed to the present lowered production.

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The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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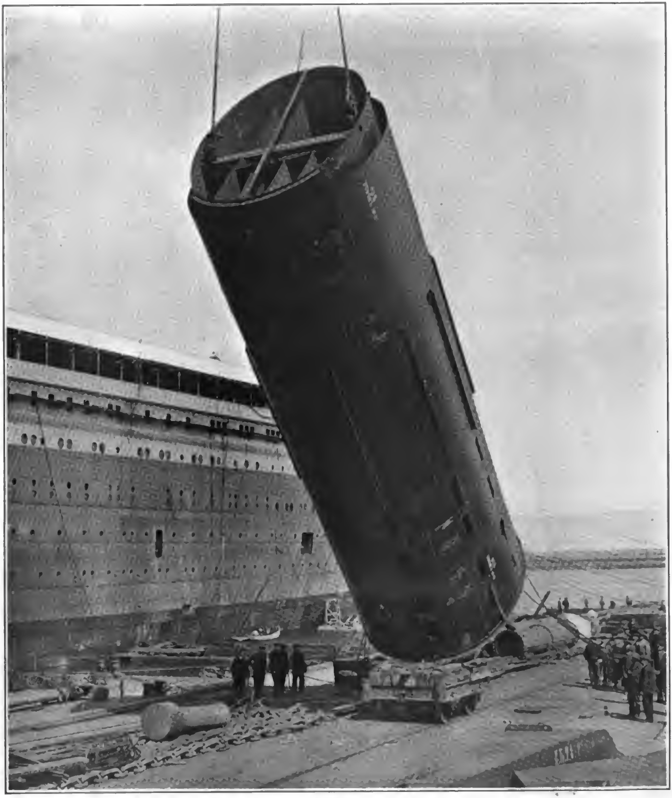

Hoisting a section of a funnel into place on an Atlantic liner.

THE BIG ATLANTIC LINERS.—[See page 260.]

Modern Research in the Metallurgy of Iron—I*

How Wonderful New Qualities and Properties Are Being Developed

By Allerton S. Cushman, Director, The Institute of Industrial Research, Washington, D. C.

Of all the seventy or eighty elements of which the materials of the universe, as revealed and proved by the spectroscope and chemical research, are found to be made, there is none so interesting to mankind as iron.

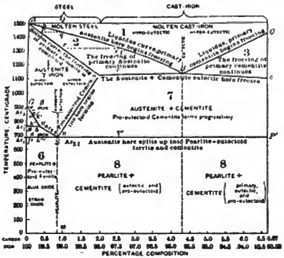
STEEL
CAST-IRON
MOLTEN STEEL
MOLTEN CAST-IRON
HYPO-EUTECTIC
HYPER-EUTECTIC
1
2
3
Liquidus curve, primary austenite here begins freezing
Liquidus, primary cementite begins freezing
The freezing of primary Austenite continues
The freezing of primary cementite continues
AUSTENITE γ IRON
The Austenite + Cementite eutectic here freezes
7
AUSTENITE + CEMENTITE
Pro-eutectoid Cementite forms progressively
Ar3
Ar2
Ar1
Ar3.2
Austenite here splits up into Pearlite = eutectoid ferrite and cementite
6
PEARLITE + Pro-eutectoid Ferrite
8
PEARLITE + CEMENTITE (eutectic and pro-eutectoid)
8
PEARLITE + CEMENTITE (primary, eutectic, and pro-eutectoid)
PEARLITE
TEMPERATURE, CENTIGRADE
CARBON 0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 6.67
IRON 100 99.5 99.0 98.5 98.0 97.5 97.0 96.5 96.0 95.5 95.0 94.5 94.0 93.5 93.33
PERCENTAGE COMPOSITION

Fig. 1.—The carbon-iron diagram (Howe).

The terms "iron" and "steel" are more or less vaguely differentiated, both by the layman and the professional metallurgist. Therefore, before proceeding further with our subject, it will be well if we understand, at least for the time being, just what we mean by these terms. There is a difference of opinion even among scientific men who have spent their lives in metallurgical research in regard to the exact definitions of the words "iron" and "steel." For our present purposes, however, let us take refuge in the common definitions as given in the dictionary, to which the layman of the world turns for information in regard to the meaning of the words which he employs. Webster's New Century Dictionary defines iron very simply as the most common and useful of the metals, and this same authority defines steel as refined iron combined with carbon. These definitions, which the writer accepts as true ones both from the standpoint of common usage and scientific interpretation, lead us naturally to the introduction of the subject under discussion in this paper, namely, modern research in the metallurgy of iron and steel. Before proceeding further into our subject, however, it is necessary to pause long enough to point out that research work can be classified very readily under separate headings. In ancient times research work into the capabilities of metallic iron was confined to the wonderful old smiths and artisans who produced, by the crudest means, examples of hardened steel whose qualities and character challenge the admiration of, and, perhaps, even to some extent defy imitation by, modern methods. All that the ancient artisan found out he usually kept to himself, or at best he divulged his secrets only to his own apprentices and immediate disciples. With this form of research work we are not at present concerned. Modern scientific methods, however, can be considered under two main heads which I shall distinguish as plant and laboratory research. When Bessemer and his contemporaries, some fifty or sixty years ago, conceived the idea of refining iron on the large scale of operation by the pneumatic process, that is to say, by blowing air under pressure through a mass of molten metal, the experimental work could only be done upon the plant scale of investigation, with its attendant difficulties, enormous cost, and danger. It has been, comparatively speaking, only within the last two decades that laboratory research in iron metallurgy has come to the assistance of the clumsier and more cumbersome method of plant scale investigation. It must at once become apparent that the most useful and the richest field is opened up where the laboratory investigator and the man who knows how to work enormous masses of metal at high temperatures join hands with a common purpose in view.

As has already been suggested, one of the extraordinary characteristics of iron depends upon the fact that it possesses an affinity for the element carbon, and combines with small quantities of this element in such a manner as to completely change its inherent characteristics. In other words, iron dissolves and seeks to dissolve in itself carbon, and it is this tendency which bears within itself potentialities of a most wonderful and extraordinary nature. I can best introduce this particular phase of the subject by making reference to what is known to metallurgists as the *Carbon-iron diagram*, which has been accurately worked out by research students, and which as completely maps the possibilities lying within the combination of cast iron on the one hand and pure iron and high carbon steels on the other, as the geographical map is capable of placing before us a broad purview of the whole or a portion of the earth's surface. This diagram has been worked out with the aid of the microscope and by modern pyrometric methods for measuring high temperatures, even as high as those known to exist in the sun, with great accuracy, both lines of research representing to a great extent a very modern development.

The carbon-iron diagram, as worked out in its entirety by our own distinguished metallurgist, Henry M. Howe, is shown in Fig. 1. For the sake of simplicity a detail of a portion of the diagram is shown in Fig. 2.

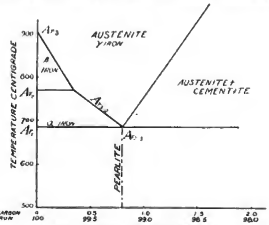

Fig. 2.—Detail of iron-carbon diagram.

I cannot attempt, in the limited time allotted to me, to elucidate all that the iron-carbon diagram has opened up to us, but must content myself with pointing out some interesting and salient features.

It has been known for a long time that if we heat iron or steel gradually until we arrive at the melting point of the metal, the rate of heating does not proceed uniformly. In the same way, if we start with iron or steel in the molten condition and cool it gradually, in both cases, at certain fixed temperatures, retardations in heat changes occur. These points are known as "critical points" or "critical temperatures." They are unquestionably caused by physical changes whereby heat is liberated at the critical points on cooling, or absorbed on heating. The three principal critical points which have been mapped are designated as A_1, A_2 and A_3. On account of molecular inertia or lag, these changes occur at lower temperatures on cooling down than on heating up, unless the rates of heat changes are infinitely slow. To distinguish them, the cooling points are designated as AR_1, AR_2 and AR_3, while the heating points are written AC_1, AC_2 and AC_3. So decided are some of these extraordinary liberations of heat that the temperature of the cooling mass may be even raised slightly, and, when the observer is in the dark, a sudden glowing may be seen. This phenomenon is termed recalescence, and has been made the subject

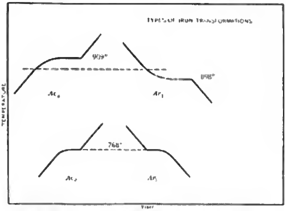

Fig. 3.—Diagrammatic curve of critical points of pure iron.

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* Read before the Franklin Institute and published in the *Journal* of the Institution.

of much research work and inquiry, a number of theories having been edvanced to explain what takes place. The commonly accepted explanation is that iron exists in at least two, and possibly three, allotropic modifications, and that the heat which is given off or absorbed, as the case may be, represents the energy of atomic rearrangements which are taking place.

A very familiar example of an element which exists in several allotropic modifications, without changing its chemical constitution, is that of ordinary carbon. One allotropic form of this element is the diamond, while a piece of charcoal or a piece of graphite may represent two other allotropic modifications. In the same way, then, we are to understand that iron is capable of existing in different modifications, and that these interesting critical points are simply the temperature points at which these changes of form take place. According to the best authorities, as described by G. K. Burgess:[1]

"The question of the allotropy of iron, in spite of a vast amount of experimental work and perhaps an even greater amount of theorizing, is not yet settled. That there is a definite transformation in iron near 900 degrees, the A_3 point, is generally recognized, as well as the fact that the temperature of this transformation is lowered by the addition of carbon and metallic elements. On heating the transformation Ac_3 is alwaye found at a higher temperature than the transformation Ar_3 on cooling. Whether the A_2 transformation is sharp, like the melting-point of a pure substance, or extends over a considerable range of temperatures, embracing perhaps at a lower limit the A_2 change, appears to be still an open question for pure iron. The nature and identity of the A_2 transformation, it would appear from recent publications, has not yet been satisfactorily settled."

It seems at least to be generally conceded that the critical points A_2 and A_3 divide iron into separate allotropic forms. These are defined as α, β, and γ iron, γ iron exists above A_3 and α iron below A_2. The A_2 point may or may not be another transition point, so that at the present time the existence of a β modification between A_2 and A_3 is in debate. The subject is too involved for discussion in this paper, but in any event it is certain that an interesting change or transformation takes place at the point A_2 which is associated mainly with the loss of the interesting property of magnetism which α iron exhibits. If chemically pure iron is the material under investigation, these critical points can be simply plotted on a diagrammatic curve, as published by G. K. Burgess and his co-workers, and shown here in Fig. 3. When steels of varying composition are under consideration, however, these critical points, as shown on the iron-carbon diagram, indicate all sorts of interesting changes which may take place.

That branch of metallurgy which treats of the constitution and structure of metals and alloys is known as metallography, and, with the aid of the microscope in the hands of research students, a number of different definite constituents of iron and steel have been distinguished, studied, and named. Among these constituents it is necessary to define the following.

Ferrite is the name applied to pure iron, and is employed to designate that part of iron or steel which is not in combination with carbon, but which may have crystallized out from a solidifying mass, in the practically pure condition. Ferrite is easily recognized under the microscope by its characteristic grain.

Cementite is the name given to a carbide of iron having a definite formula (Fe_3C). It represents a normal carbide of iron which also crystallizes out as a molten mass of carbon steel solidifies.

If a solution of common salt in water, such as sea water, is cooled at certain temperatures, depending upon the percentage of salt present, either salt or ice commences to crystallize out, and this action continues until the remaining solution, called the "mother liquor," has a definite composition, when it finally freezes out together in a mixture of minute plates of alternate ice and salt, which is scientifically known as cryo-hydrate. Whenever a similar action takes place in the cooling and freezing of molten alloys, the terms "mother metal" or "magma" and "eutectic" are substituted for mother liquor and cryo-hydrate, respectively. An interesting constituent which is always found in ordinary carbon steels which have been cooled in the usual way is a eutectoid or eutectic-like substance, consisting of a mixture of alternate minute plates of ferrite and cementite crystallized out. When a sample of the solidified steel is highly polished and slightly etched with an acid body and examined under the microscope, this constituent appears as a pearly iridescent substance, and is known to metallurgists by the appropriate name of *pearlite*. These separate substances, which we have defined as ferrite, cementite, and pearlite, are the three most important constituents of steel which are ordinarily considered. The amount of pearlite, ferrite, or cementite, in different compounds of iron and carbon, as shown graphically by O. M. Becker,[2] a well-known authority, is given in Fig. 4. The line of abscissæ here represents the amount of carbon present and the ordinates the amount of the three constituents. In addition to these constituents, however, the research student of iron and steel has to take into consideration a number of other important constituents which have been for the most part named after distinguished research metallurgists. Thus we have to consider such constituents as austenite, martensite, troostite, sorbite, and osmondite.

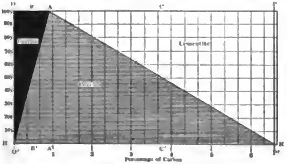

Fig. 4.—Constituents of annealed carbon steels.

In a general way it may be explained that some or all of these carbon-iron constituents are formed when steel which has been heated to some temperature above the critical point A_1, but below the melting point, is suddenly quenched in water or oil, and then perhaps slowly reheated or tempered. Such action is now known in a general way as "heat treatment." For instance, if a carbon steel containing about 1.5 per cent of carbon is heated to 1,100 deg. Cent. and then suddenly plunged into cold water, a so-called solid solution of iron carbide (cementite) in pure iron (ferrite) is suddenly locked or fixed in the structure of the steel. This is the austenite of modern metallurgical research. If such a metal is subsequently annealed by prolonged heating, the austenite breaks down again into the softer pearlitic structure. This is an important point, and should be borne in mind in order to make clear what we shall discuss later. Martensite is used to designate a transition from between austenite on the one hand and ferrite and cementite (pearlite) on the other, and is a varying combination of the three constituents. Troostite, sorbite, and osmondite we need not take time here to define in detail. In general, they are terms used to designate transition forms between the constituents already described. Pure iron, of course, consists only of ferrite, and contains none of these various carbon constituents.

All this scientific nomenclature is of special interest to the immediate purpose of this paper only to the extent that it serves to illustrate what modern research has done, and is now doing, to explain and elucidate the extraordinary characteristics of iron and steel. The old-fashioned smith or artisan quenched and tempered his steels and was guided to his result by watching the characteristic colors imparted to his metal by the changes from one constituent to another. The modern metallurgist no longer trusts his eyes, but is guided along his path of development by the aid of the microscope and pyrometer. As a distinguished authority has stated:[3]

"For at least a thousand years, and probably for several thousand, there had been no single important advance, no one striking development, in the nature and characteristics of steel, in respect to metal-cutting qualities, at any rate. The property of becoming hard, possessed in common by all steels, and distinguishing them from ordinary iron, is due to the presence of carbon diffused throughout the mass of the metal. How the presence of the particles of carbon brings about the virtue of hardening is yet a matter of discussion.

"Modern steel making is a fact only because the science of chemistry, itself scarcely a century and a half old, has made it possible to understand that there is an affinity of certain elements for certain others, and that under given conditions exactly the same combinations can be expected in chemical compounds and alloys. The prehistoric steel makers had no idea that in firing iron with certain fuels they were carbonizing it, actually forming of the iron and fuel a new substance which contained besides iron the same element which in one form constitutes charcoal, in another graphite, and in a third diamond. That, however, is exactly what they did."

The salient fact which makes research work in the field of iron and steel metallurgy so fascinating and valuable is the rich possibilities involved in its exploitation. The writer imagines, without knowing from personal experience, that the fascination of the pursuit of the study of music to a real musician or composer must reside in the almost infinite possibilities which lie within combinations of harmonies and musical themes. To a very considerable extent the modern metallurgist is a composer who is playing on a combination of almost limitless possibilities. If there is any one reason more than another which proves this statement true, it depends upon these two facts: First, because either by an accident of nature or by design the two elements, iron and carbon, possess affinities which cause them to combine in a succession of almost harmonic possibilities; and, second, because iron also has the power of linking up or combining with or dissolving in itself nearly all of the other material elements in such a manner and with such a character that the most minute quantities of these elements or combinations of them produce differences in the resulting metal or alloy, of the most profound and important nature. Allow me to dwell briefly on this idea.

It is an interesting fact that out of the seventy to eighty elements which comprise, as it were, the building blocks of the material universe, only about twelve or fourteen are commonly used either by Nature or by man. All the others are what may be generally classed as rare elements, even the names of which sound strange and unfamiliar to the ears of men of ordinary education. These rare or rarer elements seem to comprise Nature's scrap-heap, into which scientific man is painstakingly digging and delving in the effort to gain something from it for his purpose. What the chemist and physicist has done with this scrap-heap is prominently before us in these days, for he has discovered and introduced to us such wonder elements as radium and thorium, and now he is finding a use for the extraordinary element selenium, which changes its electrical conductivity under the influence of light and other sources of radiant energy. I would not like to prophesy as to the wonders man may accomplish in the future, due to this unusual and unique property possessed by the element selenium. But to return to our subject, I wish to point out that the research metallurgist has not been idle in poking about in Nature's scrap-heap for elements to combine with iron, and thus increase the wonder working properties of this already wonderful metal.

(To be concluded.)

Measurements of Radio-activity in Water

THE radioactivity of water and of the gases contained in water is measured by the effect produced on a charged electroscope by radium emanation (niton), a gas that is given off by radium-bearing minerals in proportion to their content of radium. The general opinion that most spring waters do not contain radium itself, but radium emanation derived from contact with radium-bearing minerals is logically based on the fact that nearly all spring waters gradually lose their radioactivity after being removed from the source, whereas a solution of a radium salt, after having once reached equilibrium, continues to give off radium emanation. The sample of water is boiled to drive off the emanation, which is dried and then swept by a current of air into an airtight electroscope. The latter instrument consists essentially of a jar from the cover of which is suspended a rod supporting at its lower extremity a metal strip and a leaf of aluminium foil. When the system is electrically charged the aluminium foil is deflected from its vertical position, to which it normally returns very slowly as the charge is dissipated. If, however, radium emanation is present in the jar the rate of leakage and consequently the rate of fall of the foil are greatly accelerated. The rate of leakage in the presence of the emanation from a measured quantity of water is therefore observed and compared with the rate of leakage similarly measured on the emanation from a solution of a weighed portion of a mineral whose content of radioactive substance has been determined. From these data the radioactivity of the sample of water can be calculated. The results of such measurements have unfortunately been expressed in a great variety of units, and as a natural consequence it is impossible to compare some reports of radioactivity with others. In England and America it is customary to express radioactivity as an equivalent of radium or of uranium, a radioactive substance; on the Continent it is customary to express the results in electrostatic units. It is quite general, irrespective of the unit, to report the radioactivity per liter of water or per liter of the gas in the water. The quantity of emanation in equilibrium with 1 gramme of radium is known as a curie of emanation, but as this is a very large unit estimates are expressed in fractional parts of a curie; thus, 22.9×10^{-9} curie per liter means that one liter of the water contains 229 ten-billionths of the quantity of emanation in equilibrium with 1 gramme of radium. The mache unit, frequently encountered in reports of radioactivity, is defined as the saturation ionization current due to the radium emanation, free from decay products, from a liter of water or gas, expressed in electrostatic units (i) multiplied by 1,000; and 1 curie of emanation per liter equals a concentration of 2,670 million mache units.—R. M. Dole in *Mineral Resources of the United States*, 1913. Part II; 24.

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[1] "Critical Ranges A_2 and A_3 of Pure Iron." G. K. Burgess and J. J. Crowe; Scientific Paper, U. S. Bureau of Standards 213, p. 310.

[2] "High Speed Steel"; Becker, p. 26.

[3] Becker, *loc. cit.*, p. 7.

A Crew for Big Aircraft

The Sikorsky biplane is significant of future developments. Hitherto the pilot while steering and controlling the aeroplane has also at the same time controlled the motor. But it is obvious that with a multiple power plant this is no longer possible, and accordingly on the Sikorsky the pilot operates the aeroplane controls proper, while an engineer is in charge of the motor controls, receiving his orders from the pilot. The growing necessity for some such division of labor has long been apparent in these days, when the length of flight has been increasing so rapidly, and the pilot, in addition to his other arduous duties, has had to undertake those of navigator. In time to come and for long journeys the control of the giant machines of the future will no doubt be still further subdivided. The pilot will confine his attention purely to the flying and steering of the aeroplane; an engineer will be in charge of the motors; while a navigating officer will map out the course and, if necessary, take the required observations, astronomical or otherwise.—*London Daily Telegraph.*

The Big Atlantic Liners

Some Details That Help to an Appreciation of Their Remarkable Proportions

The pictures of the monster steamships that ply the Atlantic between the United States and Europe usually show the vessels as a whole in open water, and it is difficult for those without special means of judging to gain an adequate idea of their vast proportions; a few illustrations, therefore, of some of the individual parts, with figures and explanations, will furnish a better basis for comparison and a more thorough appreciation of the giant scale to which the floating cities have been built.

The illustrations used in this article show portions of the English steamer "Britannic," which was launched early in 1914, the principal dimensions of which are as follows:

Length over all	882 feet 6 inches
Breadth, extreme	93 feet 6 inches
Draft, loaded	34 feet 7 inches
Displacement	Over 53,000 tons
Sea speed	21 knots
Number of decks	9
Passenger accommodations:	
First class	790
Second class	836
Third class	953
	2,579
Crew	950
Total	3,529

The illustrations herewith shown were taken during the building of the vessel, and the first one, on the first page, shows one of the enormous funnels in process of being hoisted into place on the ship. This great chimney is 150 feet high above the furnace bars, and it will be noticed that it is not round but elliptical in cross-section, being 24 feet 3 inches in one diameter and 19 feet 10 inches in the other, big enough to drive two of the largest size trucks through abreast and fully loaded. There are four of these great stacks, and with each one about twenty uptakes are connected, some of which come from several furnaces, for these four funnels have to take care of the smoke and gases from 150 furnaces.

The ship is driven by three propellers, the two on the outside being operated by vertical triple-expansion, reciprocating engines of 16,000 horse-power each, while the center screw is connected with an immense low-pressure steam turbine that delivers 18,000 horse-power, making a total of 40,000 horse-power; and to supply these motors with the necessary steam for their operation requires the evaporation of 700,000 pounds of

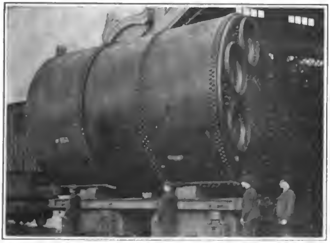

Fig. 2.—One of the twenty-nine boilers required to produce steam on a big ship.

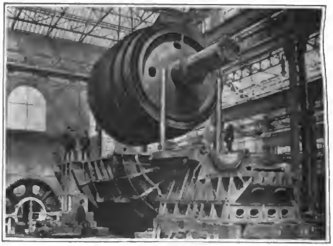

Fig. 3.—The "rotor" of an 18,000 horse-power turbine.

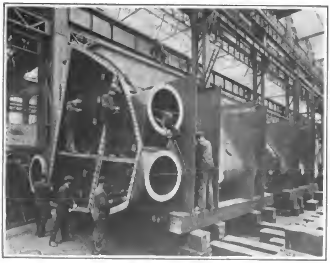

Fig. 4.—Making tight the tubes of one of the condensers.

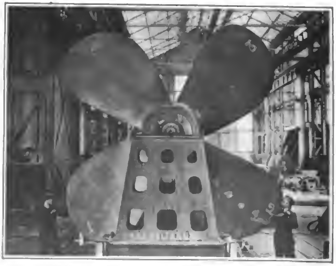

Fig. 5.—Balancing and smoothing a propeller wheel.

water every hour, or enough to supply a town of over 5,000 population for a whole day. To perform this work there are twenty-nine great boilers, five of which are what are called single boilers, and have furnaces in one end only, while the other twenty-four are double, and are provided with three capacious furnaces in each end. Fig. 2 shows one of these latter boilers, and its unusual size can be judged by comparison with the men standing by it. This boiler is 21 feet 10 inches long and 16 feet 5 inches in diameter, and is constructed with an outer shell of steel plates over an inch and one-half thick to withstand the working steam pressure of 215 pounds.

Fig. 3 gives some idea of the powerful propelling machinery, and shows the "rotor," or working part of the low-pressure turbine. This is a great cylinder, or drum, on the outer surface of which are fixed thousands of long narrow blades, set in regular rows around the body of the rotor, which is mounted on a shaft that is 3 feet in diameter in the bearings. The rotor is 12 feet 6 inches in diameter and 14 feet 11 inches long, and weighs about 150 tons complete; and it turns at 170 revolutions per minute when delivering its 18,000 horse-power. After the high-pressure steam has been used in the reciprocating engines it passes on to this big turbine, which it reaches at an actual pressure of 10 pounds, and after passing the rotor is exhausted in two condensers at about 28 inches vacuum when the barometer stands at 30 inches. As this low-pressure steam impinges on the blades of the rotor but a small amount of power is imparted to each one; but this insignificant increment multiplied by the thousands of blades, each of which adds its tiny mite, and also multiplied by the number of impulses that each contributes each minute, all foots up to the very substantial total mentioned above.

After the steam has performed its final task in the turbine it passes to the condenser, where it is reconverted into water, which is fed back into the boilers to again be made into steam. Salt water is not desirable for steam making, so fresh water is used entirely, and as it would be impossible to carry enough fresh water for a voyage if the steam is wasted, it becomes necessary to save the waste steam, and so recover the water. The condenser is a large vessel in which there are a large number of brass tubes extending between partition plates located near the ends of the condenser. The steam is passed through these tubes, while outside and around them pours a flood of cold sea water which is constantly renewed and circulated through the condenser by large pumps. In the condenser shown in the illustration, Fig. 4, which is lying on its side, there are 9,620 of the small brass tubes, which would form a length of 25 miles, and the two connections shown on the right are for the admission and escape of the cooling water.

Of the three propeller wheels, the center one, driven by the turbine, is the smallest, being but 10½ feet in diameter. The wheel, which is of solid manganese bronze and weighs 22 tons, is shown in Fig. 5, where it is mounted on a pair of smooth, straight edge rails for the purpose of testing its balance, and the men seen in the picture are engaged in the important task of smoothing and sharpening the edges of the blades, for a rough, thick edge needlessly consumes a great amount of power that is entirely wasted. The two wing propellers, which are driven by the two reciprocating engines, are each 23½ feet in diameter, and have bronze blades bolted to cast steel hubs.

The Anschütz Dead-Reckoner*

By Von Wolfgang Otto

In nautical language, a ship's reckoning denotes the position of the vessel at a given instant, which may be represented by a point marked on the chart. The reckoning is astronomical if it is computed from observations of the sun, moon, or stars, combined with the reading of the chronometer. It is terrestrial if it is derived from observations of lighthouses or other landmarks. When neither shore nor sky can be seen, as in cloudy weather far from land, the ship's position must be obtained by "dead reckoning," i. e., by drawing on the chart, from the last surely determined position, a line in the direction of the course subsequently followed, and of a length corresponding to the distance traveled in the interval, as deduced from the elapsed time and the readings of the log. Whenever the course is changed, the new course must be drawn from the end of the old one, with proper allowance for the drift caused by wind and current.

It is not difficult to obtain the ship's position by this graphical method so long as the vessel's course and speed remain nearly constant, as they usually do in the case of passenger steamers. With warships, which frequently vary their course and speed, the problem becomes very complex, and only an expert can estimate with any approach to accuracy the effects produced by the changes in speed and by the great arcs traversed in changing the course. Yet it is exceedingly important to know the exact position of the vessel at any instant, especially in time of war, so that (for example) a scout cruiser, on sighting the enemy's fleet, can immediately report its location to headquarters by wireless signals.

The problem is solved completely by the automatic dead-reckoner invented by Dr. Anschütz-Kaempfe. The readings of this instrument require correction only for the effects of wind and current. All other influences are continuously measured with great precision, and their effects are drawn on a sheet of paper to the scale of the chart, by purely mechanical means.

It might be supposed that an apparatus capable of such a performance must be very complicated, but in reality the basic principle of its operation is quite simple, for all that is required is the product of two factors: the course and the speed of the vessel.

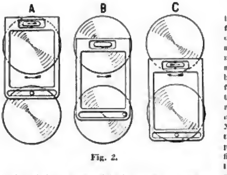

Fig. 2.

The speed is measured by a small turbine attached to the hull of the ship. The rotary movement of the turbine is transmitted to a disk. Each face of this disk touches the rim of a small wheel, the planes of the two wheels being perpendicular to the disk and to each other. The wheels are connected with the Anschütz gyrostatic compass by appropriate transmission mechanism in such a manner that the deflections of the compass cause them to move along mutually perpendicular diameters of the disk, parallel to their axes. In this way the velocity of the ship is resolved into a north or south, and an east or west, component. For example, if the vessel is moving due north, one of the wheels (shown at *A*, Fig. 2) is at the edge of the disk and is consequently rotating with the greatest rapidity it can have with the given velocity of the disk, which is proportional to the momentary speed of the vessel. In the same conditions the other wheel (at the back of the disk and not shown in the diagram) is at the center of the disk and is not rotating. When the course is due east or west the north-and-south wheel is motionless at the center (*B*, Fig. 2), while the east-and-west wheel is at the edge and is taking up the whole motion of the disk. When the course is due south the north-and-south wheel is at *C* and rotating in a direction opposite to that of its rotation at *A*. In any other course of the vessel (NE, SSW, etc.) each wheel is in a position intermediate between the center and the rim of the disk and is rotating with a velocity proportional to the north-and-south (or the east-and-west) component of the vessel's speed. Each wheel reverses its rotation as it passes the center of the disk and each is connected with counting mechanism, which works both ways. Hence, the progress of the vessel to north or south and to east or west can be read directly from the dials.

The two components are recombined in the graphical recorder of the apparatus, in which the pencil is moved horizontally by one component and vertically by the other. The drawing, therefore, gives a complete picture of the evolutions of the ship.

The first practicable apparatus of this kind has been in continual use for more than two years on the battleship "Moltke" and has proved eminently successful. Experiments had previously been made with many similar devices, but all of these lacked the most important feature, the gyrostatic compass, which is free from the defects and irregularities of the magnetic compass and is also able to exert and transmit great mechanical force.

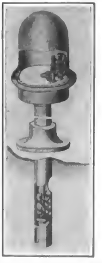

Fig. 1.—Log and turbine of the Anschütz dead-reckoner.

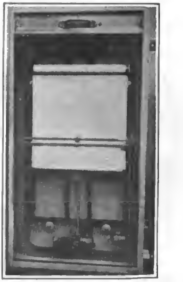

Fig. 3.—The graphic recorder.

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* Translation from Umschau.

Therapeutic Uses of Radioactive Waters

Radioactive waters are applied to the body in practically every manner that mineral waters have heretofore been used; baths, douches, and local applications of every description are employed, and the waters are also drunk and injected. In addition to these methods of administration, rooms or closets, called inhalatoria and emanatoria, are so arranged that patients may breathe the radium emanation in the gases that escape from the waters. The more completely equipped watering places have arrangements for combination of radium treatment with electric, muscular, aqueous, and other kinds of massage, hot-air baths, mud baths, and X-ray and violet-ray treatment. At some sanatoriums these treatments are given by means of waters, muds, packings, and compresses that have been rendered artificially radioactive. A great variety of diseases are treated, among which may be mentioned especially croupous pneumonia, bronchitis, bronchial asthma, articular rheumatism, tuberculosis, syphilis, gout, diabetes, and obesity. In reference to the physiologic reactions following treatment by the radioactive waters of Bath, Atkins, and Harrison are quoted by Low (Lancet, April 20th, 1912) as saying that radium increases diuresis, excretion of uric acid, and exhalation of carbon dioxide; lowers the pressure of the blood and decreases its viscosity; increases the rate of decomposition of uric acid; inhibits inflammation; increases sexual vitality; and has considerable influence over sympathetic affections. As a concluding comment on this topic, it is well to repeat that there is much conflicting testimony on the therapeutic value of radioactive waters and that the physiologic effects of relatively strong solutions of radium salts may not necessarily be duplicated by weakly radioactive natural waters.—R. B. Dole in *Mineral Resources of the United States*, 1913, Part II: 24.

Man as a Geographical Agency

The New Geography to be the Record of Changes Made by Man

In his presidential address before the Geographical Section of the British Association for the Advancement of Science in Australia, Sir Charles P. Lucas reminded his hearers that the earth is now quite well known from pole to pole, and that, although there remains some work to be done in clearing up the details of a few corners, discovery pure and simple is passing away. But he calls attention to a statement of Sir Clement Markham, formerly president of the Royal Geographical Society, that "Geography is a description of the earth as it is in relation to man," and makes the point that, in view of the rapidly increasing changes that are being made by man, changes that not only alter the outlines, but the character and climate of the earth's surface, geography in the future will be rather a record of the changes which successive generations of man have made and are making in the earth. In developing his ideas of the new geography the speaker had the following to say.

The writer who used this phrase, "Man is a geographical agency," the American writer, Mr. G. P. Marsh, published his book, "Man and Nature," in 1864, and a new edition, entitled "The Earth as Modified by Human Action," in 1874. He was mainly concerned with the destructiveness of man in the geographical and climatic changes which he has effected. "Every plant, every animal," he writes, "is a geographical agency; man a destructive, vegetables, and in some cases even wild beasts, restorative powers"; and again: "It is in general true that the intervention of man has hitherto seemed to insure the final exhaustion, ruin, and desolation of every province of nature which he has reduced to his dominion." The more civilized man has become, he tells us, the more he has destroyed.

He took this gloomy view mainly on account of the mischief done by cutting down forests. Man has wrought this destruction not only with his own hand, but through domesticated animals more destructive than wild beasts, sheep, goats, horned cattle, stunting or killing the young shoots of trees. "Man," he says, "has too long forgotten that the earth was given to him for usufruct alone, not for consumption, still less for profligate waste."

The damage done by cutting down trees, and thereby letting loose torrents which wash away the soil, is or was very marked in the south of France, in Dauphiné, Provence, and the French Alps. With the felling of trees and the pasturing of sheep on the upper edge of the forest—for sheep break the soil and expose the roots—the higher ground has been laid bare. Rainstorms have in consequence swept off the soil, and the floods have devastated the valleys. The mountain sides have become deserts, and the valleys have been turned into swamps. "When they destroyed the forest," wrote the great French geographer, Reclus, about thirty years ago, "they also destroyed the very ground on which it stood"; and then he continues: "The devastating action of the streams in the French Alps is a very curious phenomenon in the historical point of view, for it explains why so many of the districts of Syria, Greece, Asia Minor, Africa, and Spain have been forsaken by their inhabitants. The men have disappeared along with the trees; the axe of the woodman, no less than the sword of the conqueror, have put an end to, or transplanted, entire populations."

How far has the agency of man altered, and how far is it likely to alter, the surface of the earth, the divisions and boundaries assigned by nature, the climate, and the production of the different parts of the globe; and, further, how far, when not actually transforming nature, is human agency giving nature the go-by? It should be borne in mind that science has effected, and is effecting transformation, partly by applying to old processes far more powerful machinery, partly by introducing new processes altogether; and that, as each new force is brought to light, lands and peoples are to a greater or less extent transformed. The world was laid out afresh by coal and steam. A new readjustment is taking place with the development of water power and oil power. Lands with no coal, but with fine water power or access to oil, are asserting themselves. Oil fuel is prolonging continuous voyages and making coaling stations superfluous. But of necessity it is the earth herself who gives the machinery for altering her own surface. The application of the machinery is contributed by the wit of man.

The surface of the earth consists of land and water. How far has human agency converted water into land or land into water, and how far, without actually transforming land into water and water into land, is it for practical human purposes altering the meaning of land and water as the great geographical divisions? A writer on the Fens of South Lincolnshire has told us: "The Romans, not content with appropriating land all over the world, added to their territory at home by draining lakes and reclaiming marshes." We can instance another great race which, while appropriating land all over the world, has added to it by reclaiming land from water, fresh or salt. Now the amount of land taken from water by man has been taken more from fresh water than from sea, and, taken in all, the amount is infinitesimal as compared with the total area of land and water; but it has been very considerable in certain small areas of the earth's surface, and from these small areas have come races of men who have profoundly modified the geography and history of the world. This may be illustrated from the Netherlands and from Great Britain. The crowning vision of Goethe's Faust is that of a free people on a free soil, won from the sea and kept for human habitation by the daily effort of man. Such has been the story of the Netherlands. Instances of reclaiming land might be indefinitely multiplied.

How far has land been drowned by the agency of man? Again the total area is a negligible quantity, but again, relatively to small areas, it has been appreciable, and the indirect effects have been great. The necessities of town life are responsible for new lakes and rivers. Such are the great reservoirs and aqueducts by which water is being brought to New York from the Catskill Mountains, a work which a writer in the *Times* has described as "hardly second in magnitude and importance to the Panama Canal." A still larger volume of water is gathered by the great Assouan dam, which holds up the Nile at the head of the First Cataract, washing, and at times submerging, the old temples on the Island of Philæ in mid-stream. Take again the great ship canals. The Suez Canal runs for 100 miles from sea to sea, though for part of its course it runs through water, not through sand. It is constantly growing in depth and width. A writer in the *Times* on the wonderful Panama Canal said: "The locks and the Gatun dam have entailed a far larger displacement of the earth's surface than has ever been attempted by the hand of man in so limited a space." The canal is only fifty miles long from open sea to open sea, from shore line to shore line only forty. But in making it man, the geographical agency, has blocked the waters of a river, the Chagres, by building up a ridge which connects the two lines of hills between which the river flows, with the result that a lake has come into existence which is three quarters of the size of the Lake of Geneva.

Mr. Marsh, in his book, referred to far more colossal schemes for turning land into water, such as flooding the African Sahara or cutting a canal from the Mediterranean to the Jordan and thus submerging the basin of the Dead Sea, which is below the level of the ocean. All that can be said is that the wild-cat schemes of one century often become the domesticated possibilities of the next and the accomplished facts of the third; that the more discovery of new lands passes out of sight the more men's energies and imagination will be concentrated upon developing and altering what is in their keeping; and that, judging from the past, no unscientific man can safely set any limit whatever to the future achievements of science.

But now, given that the proportion of land to water and water to land has not been, and assuming that it will not be, appreciably altered, has water, for practical purposes, encroached on land, or land on water? In many cases water transport has encroached on land transport. The great isthmus canals are an obvious instance; so are the great Canadian canals. Waterways are made where there was dry land, and more often existing inland waterways are converted into sea-going ways. Manchester has become a seaport through its ship canal. The Clyde has been "converted from an insignificant stream into a deep navigable river." It is because engineers have artificially improved nature's work on the Clyde and the Tyne that these rivers have become homes of shipbuilding for the whole world. Building training walls on the Seine placed Rouen, seventy-eight miles up the river, high among the seaports of France. The Elbe and the Rhine, the giant rivers Mississippi and St. Lawrence, and many other rivers, have, as we all know, been wonderfully transformed by the hand of the engineer.

But land in turn, in this matter of transport, has encroached upon sea. In old days, when roads were few and bad, when there were no railways, and when ships were small, it was all-important to bring goods by water at all parts as far inland as possible. In England there were numerous flourishing little ports in all the estuaries and up the rivers, which, under modern conditions, have decayed. No one now thinks of Canterbury and Winchester in connection with seaborne traffic; but Mr. Belloc, in "The Old Road," points out how these two old-world cathedral cities took their origin and derived their importance from the fact that each of them, Canterbury in particular, was within easy reach of the coast, where a crossing from France would be made; each on a river. In the days when the Island of Thanet was really an island, separated from the rest of Kent by an arm of the sea, and when the present insignificant river Stour was a wide and navigable estuary, Canterbury was a focus to which the merchandise of six Kentish seaports was brought, to pass on inland; it was in effect practically a seaport. Now merchandise comes to a few large ports only, and is carried direct by rail to great distant inland centers. Reclus wrote that bays are constantly losing in comparative importance as the inland ways of rapid communication increase; that, in all countries intersected with railways, indentations in the coast-line have become rather an obstacle than an advantage; and that maritime commerce tends more and more to take for its starting place ports situated at the end of a peninsula. He argues, in short, that traffic goes on land as far out to sea as possible instead of being brought by water as far inland as possible. He clearly overstated the case, but my contention is that, for human purposes, the coast-line, though the same on the map, has practically been altered by human agency. Ports have been brought to men as much as men to ports.

But let us carry the argument a little further. Great Britain is an island. Unless there is some great convulsion of nature, to all time the Straits of Dover will separate it from the continent of Europe. Yet we have at this moment a renewal of the scheme for a Channel tunnel, and at this moment men are flying from England to France and France to England. Suppose the Channel tunnel to be made; suppose flying to be improved—and it is improving every day—what will become of the island? What will become of the sea? They will be there and will be shown on the map, but to all human intents and purposes the geography will be changed. The sea will no longer be a barrier, it will no longer be the only high-road from England to France.

Men think in years, or at most in lifetimes; they ought sometimes to think in centuries. I believe in Reclus's words, "All man has hitherto done is a trifle in comparison with what he will be able to effect in future." Science is like a woman. She says No again and again, but means Yes in the end.

In dealing with land and water I have touched upon natural divisions and natural boundaries, which are one of the provinces of geography. Flying gives the go-by to all natural divisions and boundaries, even the sea; but let us come down to the earth. Isthmuses are natural divisions between seas; the ship canals cut them and link the seas—the canal through the Isthmus of Corinth, the canal which cuts the Isthmus of Perekop between the Crimea and the mainland of Russia, the Baltic Canal, the Suez Canal, the Panama Canal. Inland, what are natural divisions? Mountains, forests, deserts, and, to some extent, rivers. Take mountains. "High, massive mountain systems," writes Miss Semple, "present the most effective barriers which man meets on the land surface of the earth." But are the Rocky Mountains, for instance, boundaries, dividing-lines, to anything like the extent that they were now that railways go through and over them, carrying hundreds of human beings back and fore day by day? On what terms did British Columbia join the Dominion of Canada? That the natural barrier between them should be pierced by the railway.

If, in the Bible language, it requires faith to remove mountains, it is not wholly so with other natural boundaries. Forests were, in old days, very real natural dividing-lines. They were so in England, as in our own day they have been in Central Africa. Between forty and fifty years ago, in his "Historical Maps of England," Prof. C. H. Pearson, laid down that England was settled from east and west, because over against Gaul were heavy woods, greater barriers than the sea. Kent was cut off from Central England by the Andred Weald, said to have been, in King Alfred's time, 120 miles long and 30 broad. Here are Prof. Pearson's words: "The axe of the woodman clearing away the forests, the labor of nameless generations reclaiming the fringes of the fens or making their islands habitable, have gradually transformed England into one country, inhabited by one people.

Can the same be said of deserts? They can certainly be pierced, like isthmuses and like mountains. The Australian desert is a natural division between Western and South Australia. The desert will be there, at any rate for many a long day after the transcontinental railway has been finished, but will it be, in anything like the same sense as before, a barrier placed by nature and respected by man? As we all know, if population be available, they bring in their train development of the land through which they pass. Are these deserts of the earth always going to remain "deserts idle"? Is man going to obliterate them? In the days to come, will the desert rejoice and blossom as the rose? What will dry farming and what will afforestation have to say? A book has lately been published entitled "The Conquest of the Desert." The writer, Dr. Macdonald, deals with the Kalahari Desert in South Africa, and for the conquest of the desert he lays down that three things are essential—population, conservation, and afforestation. He points out in words which might have been embodied in Mr. Marsh's book, how the desert zone has advanced through the reckless cutting of trees, and how it can be flung back again by tree barriers to the sand dunes. By conservation he means the system of dry farming so successful in the United States of America, which preserves the moisture in the soil and makes the desert produce fine crops of durum wheat without a drop of rain falling upon it from seedtime to harvest. If the settlers come, he holds that the agency of man, tree-planting, ploughing, and harrowing the soil, will drive back and kill out the desert.

What, again, will irrigation have to say to the deserts? Irrigation has already changed the face of the earth, and as the years go on, as knowledge grows and wisdom, must inevitably change it more and more. I read of underground waters in the Kalahari. I read of them too in the Libyan Desert. In the "Geographical Journal" for 1902 it is stated that at that date nearly 22,000 square miles in the Algerian Sahara had been reclaimed with water from artesian wells. What artesian and sub-artesian water has done for Australia you all know. If it is not so much available for agricultural purposes, it has enabled flocks and herds to live and thrive in what would be otherwise arid areas.

Thus I have given you four kinds of barriers or divisions set by nature upon the face of the earth—mountains, forests, deserts, rivers. The first, the mountains, man cannot remove, but he can and he does go through them to save the trouble and difficulty of going over them. The second, the forests, he has largely cleared away altogether. The third, the deserts, he is beginning to treat like the forests. The fourth, the rivers, he is beginning to shift when it suits his purpose and to regulate their flow at will.

I turn to climate. Climates are hot or cold, wet or dry, healthy or unhealthy. Here our old friends the trees have much to say. Climates beyond dispute become at once hotter and colder when trees have been cut down and the face of the earth has been laid bare; they become dryer and moister according as trees are destroyed or trees are planted and hold the moisture; the cutting and planting of timber affects either one way or the other the health of a district. The tilling of the soil modifies the climate.

Nowhere have the triumphs of medical science been more conspicuous than where engineers have performed their greatest feats. De Lesseps decided that Ismailia should be the headquarters of the Suez Canal, but the prevalence of malaria made it necessary to transfer the headquarters to Port Said. In 1886 there were 2,300 cases of malaria at Ismailia; in 1900 almost exactly the same number. In 1901 Sir Ronald Ross was called in to advise; in 1906 there were no fresh cases, and malaria has been stamped out. Lesseps' attempt to construct the Panama Canal was defeated largely, if not mainly, by the frightful death-rate among the laborers; 50,000 lives are said to have been lost, the result of malaria and yellow fever. When the Americans took up the enterprise they started with sending in doctors and sanitary experts, and the result, of splendid medical skill and sanitary administration was that malaria and yellow fever were practically killed out. Man is a geographical agency, and in no respect more than in the effect of his handiwork on climate, for climate determines products, human and others. Science is deciding that animal pests shall be extirpated in the tropics, and that there shall be no climates which shall be barred to white men on the ground of danger of infection from tropical diseases.

If we turn to products, it is almost superfluous to give illustrations of the changes wrought by man. As the incoming white man has in many places supplanted the colored aboriginal, so the plants and the living creatures brought in by the white man have in many cases, as you know well, ousted the flora and fauna of the soil.

Australia is the same island continent that it always was; there are the same indentations of coast, the same mountains and rivers, but the face of the land is different. In past years there was no town, and the country was wilderness; on the surface of the wilderness many of the living things were different; and from under the earth has come water and mineral, the existence of which was not suspected. A century hence it will be different again, and I want to see sets of maps illustrating more clearly than is now the case the changes which successive generations of men have made and are making in the face of Australia and of the whole earth.

More than half a century ago Buckle, in his "History of Civilization," wrote: "Formerly the richest countries were those in which nature was most bountiful; now the richest countries are those in which man is most active. For in our age of the world, if nature is parsimonious we know how to compensate her deficiencies. If a river is difficult to navigate, or a country difficult to traverse, an engineer can correct the error and remedy the evil. If we have no rivers we make canals; if we have no natural harbors we make artificial ones."

An island continent Australia is still, and always will be, on the maps. It always will be the same number of miles distant from other lands; but will these maps represent practical everyday facts? What do miles mean when it takes a perpetually diminishing time to cover them? Is it not truer to facts to measure distances, as do Swiss guides, in Stunden (hours)? What, once more, will an island continent mean if the sea is to be overlooked and overflown? The tendency is for the world to become one; and we know perfectly well that, as far as distance is concerned, for practical purposes the geographical position of Australia has changed through the agency of scientific man. If you come to think of it, what geography has been more concerned with than anything else, directly or indirectly, is distance. It is the knowledge of other places not at our actual door that we teach in geography, how to get there, what to find when we get there, and so forth. Year after year, because distance is being diminished, coming and going of men and of products is multiplying; steadily and surely the world is becoming one continent. This is what I want geographers to note and the peoples to learn. Geographers have recorded what the world is according to nature. I want them to note and teach others to note how under an all-wise Providence it is being subdued, replenished, recast, and contracted by man.

Treatment of the Wounded

At the meeting of the Academy of Sciences, held in Paris on Monday, August 10th, a paper, of particular interest at the present time, was read by Inspector General Edmond Delorme dealing with the treatment of the wounded in modern warfare.[1] General Delorme became a surgeon in the French army during the last Franco-Prussian War, and has devoted his life to the advancement of military surgery, his text-book on that subject being recognized everywhere as a standard work. His opinion of the wounds inflicted by modern weapons is by no means pessimistic:

"The military surgeons, at the present time," he writes, "must adopt the most conservative methods of treatment in the great majority of military wounds; indeed, such methods must be applied in practically every case of bullet wound. The opening of a modern bullet wound is so small that if the surgeon adopts strict antiseptic or aseptic dressings and refrains from probing the wound or making a systematic search for foreign bodies arrested in its track, it is possible to give the most favorable prognosis for wounds of this class. Thanks to aseptic and antiseptic methods of treatment, the wounded run less risk than in former times."

The pointed bullet, employed by the German army, leaves very narrow wounds of entrance and exit when it penetrates the more fleshy parts of the body, but its track in the tissues themselves is marked by a considerable degree of destruction. Still, such cases, in General Delorme's opinion, should recover in the course of several days or perhaps weeks. On the other hand, wounds from shrapnel, or from deformed bullets, are often extensive, open, and complicated by the intrusion of clothing or other foreign bodies. Such wounds are not necessarily dangerous, but they frequently suppurate and require close attention when the wounded are being transported to the hospital at the base.

One naturally pays the closest attention to what General Delorme has to say regarding wounds of the abdomen—so fatal in former wars. During the last twenty years surgeons have so improved their technique that they now perform abdominal operations as safely as those on the limbs.

"The treatment of wounds of the abdomen," writes General Delorme, "deserves the closest attention of surgeons, particularly of those working at the front. We have new methods at our disposal which may ameliorate the results of a class of cases always regarded as of grave import. The advisability of operating on such cases in civil practice is open to discussion, but the case in war is quite different. In war the surgeons must lay aside any idea of opening the abdomen. The experience of all recent war is against such means—experience in the Transvaal, Manchuria, the Balkans. In the Transvaal, even when abdominal operations were carried out by the most eminent surgeons, under the best conditions, it was found that those who were operated on yielded a smaller percentage of recoveries than the cases which were not subjected to operation."

The modern German bullet, in full flight, leaves a very small wound on the wall of the abdomen, and seldom infects the wound by carrying clothing in front of it. The perforations produced by such bullets in the loops of intestine are minute and tend to close spontaneously. In some cases the bullet may pass between loops, leaving the intestinal wall intact.

The natural and salutary inclination on the part of the wounded to relieve both bladder and bowels, allowing the patient rest for some time, instead of hurrying him to the transport, allows a natural exudate to form round the wounded parts and favors the process of healing. For wounds of this kind the ancient methods of treatment seem best: absolute repose, refraining from prolonged transport, total abstinence from food and drink for several days, rinsing of the mouth, hypodermic injections of artificial serum, the administration of opium, and placing the patient in a half-sitting (Fowler's) posture.

It will be thus seen that the leading military surgeon of France advises conservative methods of treatment. We do not doubt that he is right. During an extensive action the surgeons at the front are suddenly overwhelmed by thousands of patients. It would be impossible to undertake, even were it advisable, prolonged, and tedious operations—to give attention to one case and neglect the remaining ninety-nine. Fortunately, at least in General Delorme's opinion, such operations at the front are unnecessary; the surgeon's business is simply to see that the wounded are placed in the best circumstances to allow their natural recuperative powers to have the best chance of exerting themselves.

Much of the paper to which we have directed attention is of a purely technical nature and directly concerns only surgeons of the navy and army. But much of it concerns us all, and we are glad to think that as our arms of precision have improved our methods of treating the injuries produced by such improvements have not lagged behind.—*Nature.*

New Engineering Laboratories

The new engineering laboratories of the Dundee University College are among the best equipped in the United Kingdom. This department has been erected at a cost, including equipment, of $75,000. The main building of two stories contains lecture rooms, drawing offices, library, hydraulic laboratory, etc. An architectural feature is provided by the central tower, some eighty feet high, which houses the fan and machinery for forced ventilation of the building, and also contains a storage tank of 10,000 gallons for the piping of the hydraulic laboratory. Other quarters contain the heat-engine laboratory and boiler house, the strength of materials laboratory, cement testing room, and workshop. The heat engine room has an experimental steam engine, a gas engine and a gasoline motor, provision being made for a Diesel engine and a steam turbine. The steam engine is specially designed for experimental work and is of the horizontal compound type working with an electrically driven Worthington surface condensing plant, power being measured by an Appold brake. Speed can vary between 70 and 140 revolutions per minute, and about 100 horse-power is developed at 100 revolutions per minute with 250 pounds pressure. The National gas engine is of 30 horse-power and uses a suction producer, or city gas. Arrangements are made for measuring the amount and the heating value of fuel used, solid or gaseous. Gasoline motor is a 14-16 horse-power Argyll motorcar engine mounted stationary, power being absorbed by Prony brake or by an electric brake. Heat engine room has all the apparatus needed for measuring heat values of solid and gaseous fuels, also analysis of flue, exhaust and fuel gases, measurement of dryness of steam and the like. Steam comes from a Babcock-Wilcox boiler, with electric feed pumps.

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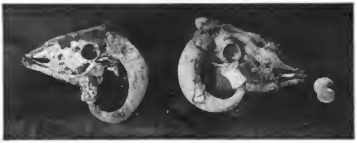
[1] "Blessures de Guerre, Conseils aux Chirurgiens." Par M. Edmond Delorme. *Comptes rendus,* August 10, p. 394.

Some Recently Discovered Nubian Antiquities*

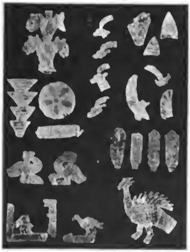
From a Garrison Which Held the Northern Sudan in the Hyksos Period, About 1700 B. C.

It might appear from an inspection of the statues and reliefs sent to the Museum of Fine Arts that the search for works of art was the only object of the Egyptian Expedition; and yet, however important these things are from the museum point of view, they can never be the sole object of an expedition which represents Harvard University as well as the Museum of Fine Arts. They are a partial product of field work aiming also at historical research. Long experience teaches that in the end the most methodical scientific work brings the best results, both artistic "finds" and historical conclusions. The great element of chance lies in the selection of a site. Once that is determined there is only one thing to do—extract all the information there is in the site, including necessarily all the antiquities.



Heads of rams with horn protectors to prevent goring. From the cemetery.

The trip to the Sudan illustrates very clearly the practice of the expedition. Considering the possibilities of various sites, I came to the conclusion that the Nile Valley from Halfa to Merowe, held as Egyptian territory since the Middle Empire, might offer a profitable field of work. Egyptian fortresses and temples were known, royal statues and decrees had been found in numbers. Another consideration of prime importance was the possibility of solving some of the questions raised by the Nubian Archæological Survey. During the survey a race and a civilization had been revealed, called by me the Nubian C-group, the date of which was fixed to the period between the Old and the New Empire, the very period for which we now needed museum material.

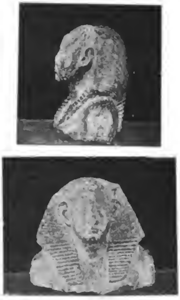


Mica ornaments sewed on caps and dresses. From the cemetery of the Hyksos period.

Casually mentioning my plans to Dr. Wreszinski of Königsberg, my attention was directed by him to Lepsius's notes on Nubia, just going through the press under Wreszinski's editorship. Lepsius had visited Kerma on June 20th, 1844, and had formed a great opinion of the place as an Old Empire site. This did not impress me; but he described at one place some rings of stones. These immediately attracted my attention, as such rings are characteristic of the graves of the Nubian C-group. I therefore resolved to include Kerma in the district to be visited. Nevertheless another site was selected for the chief point of examination, and this was Sêsi, opposite Delgo, which Prof. Breasted identified in 1907 with Gem-Aton, the southern capital of Amenophis IV (Dynasty XVIII).

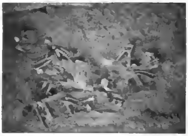
Permission was kindly given by the Sudan government for the proposed survey, and on February 8th I arrived with thirty Egyptian workmen at Merowe, the capital of Dongola Province, on my way to Sêsi (see map of Nubia).

By the time we reached Argo, the last station before Kerma, I had made up my mind that it was my duty to stop at Kerma long enough to make a thorough examination, and I telegraphed to Khartum for the necessary permission, which was promptly granted.



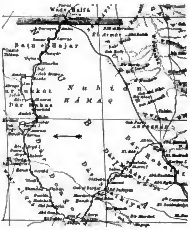
Bust of black granite statuette of a king of the XII dynasty, probably Amen-em-hat III.

Then came one of those romantic experiences which sometimes fall to the lot of the excavator—a grinding period of seemingly hopeless drudgery, a painful reconstruction of the history of the place from broken bits of things, and suddenly, quite at the end, a revelation of the civilization of the garrison of the Hyksos Period in a bewildering succession of "finds" incredibly preserved. In a few days customs were shown to us such as were never known before in this period, a race was found whose possible identification one hardly dared confess to one's self, and objects were piled up in the storerooms such as I had never hoped to see. There were wooden beds with latticed thong covering and legs carved to imitate bulls' legs (some of the legs cased in beaten gold), ostrich feather fans which could still be swung in the hand, swords with ivory and tortoise-shell handles, scarabs of the Hyksos Period, a mass of brilliant black and red polished pottery as thin and fine as good porcelain.

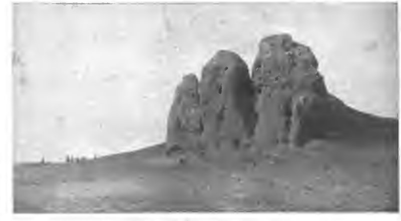


Grave, Kerma, 1065, chief burial intact on bed with sword between his legs, looking south.

On the first morning I rode a donkey over the plain at Kerma on my preliminary inspection. I had spent the night in the irrigation rest-house, which was kindly placed at my disposal by Inspector Gurney. From the house I could see a great mud ruin a few miles to the south, called by the natives the Western or Lower Defûfa. As I rode toward it the Eastern or Upper



Map of Nubia.



Western Defûfa seen from the south.

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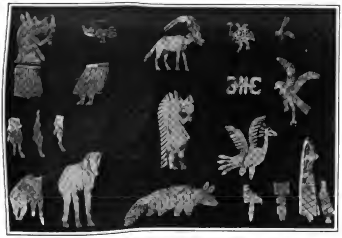
* By courtesy of the Boston Museum of Fine Arts.

Defûfa came into view about five miles to the east. Everything appeared much as Lepsius had seen it on the 29th day of June nearly seventy years ago. The ground was strewn thickly with potsherds, stone implements, and fragments of bone; the mount of potsherds was there, the granite altar—all but the dike along the Nile. This was the western side of the basin. The middle was already green crop-land, irrigated at the last inundation; and the part I was riding over was that most threatened by the next inundation. Our work was clearly marked out for us. The first thing was to examine the Western Defûfa and "the plain of potsherds."

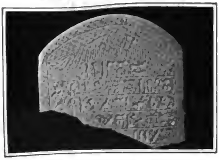
A number of potsherds and other objects were picked up on the surface, and the object register was started with these. Most of the potsherds appeared to be Nubian C-group. Four trenches were begun immediately round about the Defûfa "to determine the character of the *débris* and the presence or absence of graves." All but one of these trenches showed the layer of surface potsherds and other fragments to be about 40 to 100 centimeters thick, resting on a sub-soil of Nile mud, and with no trace of graves or structures. But in Trench 2 we came on a maze of burnt brick walls, and among them a fragment of an inscribed alabaster cup with the name of Pepy I, the king under whom was born the Impy whose unplundered tomb we had just found at Giza.

A series of walls were excavated on the west side, showing foundations of four periods of occupation. Fragments of inscribed alabaster gave us the names of Nefer-ka-Ra, Pepy I, Amenemhat I, and Sesostris I, proving that the place was occupied from the begin-

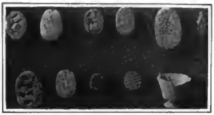


Bone and ivory inlay pieces, decorations from wooden furniture.

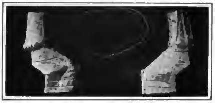
Ostrich feather fans from the great cemetery of the Hyksos period.



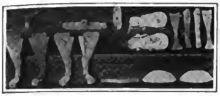
Stela of black granite dated in the thirty-third year of Amen-em-hat III (1816 B. C.), giving the ancient name of Kerma.



Nine scarabs and a golden crocodile from the great cemetery. Minute cup of blue paste with name of Sesostris I, from western Defûfa.



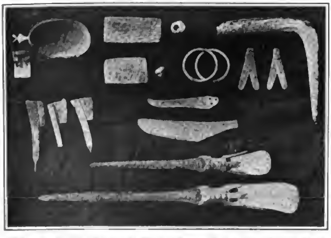
Beaten gold cases that covered the wooden bed legs, and a gold necklet with a single red carnelian bead.



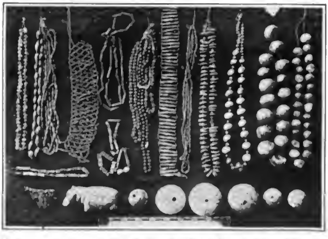
Chair legs and bed legs of wood, raw hide sandals and head rest from cemetery.

Pottery from rooms of western Defûfa.

Mud seal-impressions from the western Defûfa.



Wooden dish, kohl-palettes and bronze objects. The flies are military decorations. The hatchet-shaped tools were used as razors. The daggers have finely carved ivory and tortoise shell hilts and bronze blades. From the great cemetery.



Beads and amulets, arranged in the following order: Green glazed rock crystal, blue faience, bracelet of blue faience, blue faience, carnelian, beryl and blue faience, girdle of blue faience, two specimens of blue faience, blue faience, and two amethyst beads, two specimens of blue glazed quartz.

ning of the VI to the XII Dynasty. We followed the outline of the Defûfa around its four sides, but it was a solid mass like the under part of a fortress. On the east there was a series of rooms filled with the ashes and coals of a great conflagration, and on the floor were pots and pans, bone implements, pieces of ostrich eggs, over a thousand seal-impressions in mud, and many other remains of the last occupation—that which ended in fire. The seal-impressions fixed the date to the Hyksos Period.

Round about the Defûfa were heaps of ashes, slag, unfinished faiences, unfinished pottery, unfinished stone beads, and lumps of raw material—red hematite color (for painting pottery), gray *teriok* (for glazing pottery), lumps of malachite, natural rock crystals (for making beads), ostrich egg-shell (for making disk-beads), and mica (for making ornaments for caps and dresses). The mud seal-impressions must be considered in this same connection. They had been affixed to doors, boxes, pots, and baskets, being placed over a string knot and impressed with scarab and other seals. The abundance of the mud seal-impressions showed that they had been in use for practical purposes, probably connected with trading. From all this material it is only fair to conclude that the fort was the center of a trading and manufacturing post, at any rate during the Hyksos Period, and probably as far back as the VI Dynasty.

While the work on the Defûfa proceeded, a small gang was detailed to search "the plain of potsherds." To my surprise there was no ancient cemetery in it. It was a *plain of potsherds*, nothing more. The layer was never more than a few centimeters deep, and under it was the dark subsoil, possibly alluvial. But finally we came on a late cemetery—a thoroughly plundered burying ground of the first and second centuries A. D. The burials were only just under the surface; and unprofitable as it was, this cemetery taught us one thing—the plain had been denuded about three feet since the second century A. D. It was clear that the layer of potsherds lay on a denuded surface far below that on which lived the men of their day. The potsherds were for the greater part of types known to be as ancient as the Hyksos Period; and as they were so freely mixed with household implements and animal bones, the layer, it seems, must be all that remains of a wide-spread town of that early date. The houses have disappeared to the last vestige throughout the great plain. Only the Defûfa itself remains, and the few walls buried under the *débris* fallen from that mass of mud brick.

Four weeks went in this examination of the western side of the basin. The registers were fully kept—the diary with its sketches, the object register with near a thousand drawings, the photographs of work and objects, the register of photographs, the plans and notes on buildings, and the card record of each grave. In the end the outline of the history of the site had been pieced together from scraps. Artistically speaking, not a single thing had been found—not a thing which could be placed on exhibition in the museum. During the time from February 28th to March 12th it appeared that the whole trip would probably be a failure from the point of view of the museum collections. The only cheering thing was the fact that we were on the site of a great town of the Hyksos Period and earlier—that we had found the period at any rate for which we had come to the Sudan. Then at noon on March 11th I shifted the work to the eastern side of the basin, confident that the flooding of the western side could not rob us of any material of value.

I ordered the men to clear the first stone ring (No. III) north of the Eastern Defûfa. By evening it was finished. The ring of stones was only on the surface. It did not appear to be a retaining wall such as surmounted the Nubian C-group graves. Yet in the very middle was a plundered pit like a C-group pit in size, proportions, and orientation. The next ring examined was farther east, and before sunset on the 12th, although only a dozen plundered graves had been opened, I knew I had the cemetery of the garrison of the Hyksos Period, and that the trip was to be a success in every way.

Permit me to recall the time in which this garrison held Kerma. By 2000 B. C. the Egyptian had already begun his exploitation of the Upper Nile and had been led in military force as far as the present Province of Dongola, the richest area between the Assuan border of Egypt and the tropical Sudan. Gold he certainly brought away, and cattle; ivory, ostrich feathers and eggs, ebony, skins, resins, spices, and incense—all came through the province in trade if they were not produced here. Much of the valuable material brought down by these expeditions was probably of the nature of tribute or blackmail levied on the tribes of the Sudan. It is doubtful if anything of corresponding value was given in return. But Sebni, one of the Egyptian commanders, who led an expedition hither, took "ointment, honey, clothing, oil" to make presents. At Kerma the only certain traces left of these Old Empire military expeditions are the fragments of alabaster vessels with the name of Pepy I. Just west of the Western Defûfa, in an area about thirty feet square, in a layer of *débris* only about a foot thick we found fragments of several hundred stone vessels of the Old Empire, and other fragments were found all over the site. It is quite possible that these were distributed as royal gifts to those chiefs who were properly subservient, or, intended for this purpose, they may have been used in trade by the leader of the expedition. In any case, the great mud-brick fort was probably built by one of these Egyptian expeditions and held by them during their stay. Kerma is one of the places from which the Um-en-Nabâdi gold mines may be reached; it holds the northern entrance of the rich province of Dongola, and would have been a valuable base of operations for such an expedition.

The greater part of our knowledge of the Egyptian expeditions to Nubia in the Old Empire comes from the inscriptions which the governor of the South, Harkhuf, had carved on his tomb at Assuan. His expeditions were under Mernera and Pepy II, successors of Pepy I. But the inscription of Uni, of the time of Pepy I, distinctly states that the king raised levies of soldiers among the fortresses of the negroes of Nubia. It is, therefore, probably only a chance that no account of expeditions of Pepy I to Nubia have been found, and equally a matter of chance that no inscriptions of Mernera and Pepy II were found at Kerma.

During the period of depression in Egypt which followed the reign of Pepy II, it is probable that the Nubian tribes went their own way undisturbed. In the Middle Empire, however, the exploitation of Nubia by Egypt was resumed and placed on a more secure footing. Sesostris III set up a boundary stone at Kummeh, south of Halfa, forbidding any negro to pass northward by land or water except traders and official messengers. This stone marked the southern border of Egypt, but as a matter of course, not the limits of Egyptian activity. The region to the south was certainly laid under tribute and held in subjection by regular garrisons, both during this reign and the succeeding one. At Kerma we found a few fragments of alabaster vases with the names of Sesostris I and Amenemhat I, and a minute frit cup with the name of Sesostris (which one is uncertain). Near the door of the building No. II there was a fragment of an inscription dated in the thirty-third year of Amenemhat III.[1] Scattered over the surface of mounds IX and X we picked up fragments of perhaps twenty-five royal statuettes of the Middle Empire. These had all been intentionally smashed, and in some cases burnt with fire. In mount XI there was a small building, apparently enlarged and restored, and last occupied in the Hyksos Period, that is, in the time of the men buried in the garrison cemetery. So it is quite clear that Kerma was held by the kings of Egypt during the Middle Empire, and that the five buildings now marked down in mounds I, II, IX, X, and XI were built or reconstructed during that time.

Thus we come to the Hyksos Period itself. Much has been written about this period in Egypt, but our real knowledge is small. An unidentified race came in, apparently from Asia, conquered and held Egypt for perhaps a hundred years. But we do not know how far south they held it, nor how their administration was organized.

So we come back to Kerma, and here in the Hyksos Period is a colony of men, not negro, and yet not using Egyptian furniture nor Egyptian burial customs. They razed the buildings of the Egyptians of the Middle Empire; they smashed the statues of Egyptian kings of the XII Dynasty; and they made their graves in the *débris* of an ancient mud-brick structure. They were apparently a fierce and capable race. Their pottery, manifestly made locally, is the finest and most beautiful pottery ever made in the Nile Valley. In fact, I know nothing equal to it previous to the fine, polished paste-wares of the Greeks. Their burial customs are revolting in their barbarity. On a carved bed in the middle of a big circular pit the chief personage lies on his right side with his head east. Under his head is a wooden pillow; between his legs a sword or dagger; beside his feet cowhide sandals and an ostrich feather fan. At his feet is buried a ram, often with ivory knobs on the tips of the horns to prevent goring. Around the bed lie a varying number of bodies, male and female, all contracted on the right side, head east. Among them are the pots and pans, the cosmetic jars, the stools, and other objects. Over the whole burial is spread a great ox-hide. It is clear they were all buried at once. The men and women round about must have been sacrificed so that their spirits might accompany the chief to the other world. None of them, so far as I could observe, bore any marks of violence. Several had their fingers twisted into their hair or had covered their faces with their hands. One woman had struggled over on her back and was clutching her throat. But most of them lay composed as if minded to die quietly, according to the custom of their fathers. I could not escape the belief that they had been buried alive. Who are these people? There are, it is true, a few negroes among the women; but the chief men are all broad-headed and straight-haired. If they are Egyptian, whence comes the strange pottery and the awful burial custom?

It is hoped to submit the bones to Prof. Elliot Smith, who will, without doubt, be able to say whether the men were Egyptians or not. If they are neither Egyptians nor negroes, then there are many possibilities—Arabs, Libyans, a mixed band of adventurers from the north, or even Hyksos. The name of Sheshy, supposed to be a Hyksos king, is found on several of the seal-impressions. But it is not possible at present to reach any safe conclusion on the race of the men of Kerma. The expedition hopes to return there the coming winter and with favoring chance to unravel the mystery. There are other mounds north of the cemetery of the Hyksos Period, and they may give us remains of the earlier garrisons.

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[1] By a curious coincidence about the same time the expedition found at our old site of Naga-ed-Der a grave stela dated in the thirtieth year of Amenemhat III.

The Clothing Industry*

THE clothing industry of the United States turns out products valued at $500,000,000 every year, and of this enormous quantity over one-half is produced by the State of New York. Many of the large cities of the United States, including New York, Chicago, Philadelphia, and Baltimore, are great centers for this industry, despite the high rents that must be paid there; experience having shown that urban localization is exceedingly important, on account of the dependence of the industry on labor. In the present article we deal mainly with the manufacture of external garments. In the underwear industry the hazards are similar, but not wholly identical.

The chief implements of the garment-workers' trade are the needle, the sewing machine, the pressing iron, and the shears and cutting machines; and the workers may be classified as machine operators, hand sewers, pressers, trimmers, and cutters. There are some fifty processes involved in the making of a garment, but inasmuch as they are largely non-hazardous, we shall mention only those in which accidents are most likely to occur.

The cloth as received from the mill is first compared with the sample, and if the two agree, it is then critically examined for defects. The principal hazard in this department is that due to the possibility of the workmen being injured when handling the heavy rolls of material.

In some cases the cloth, after it has been examined, is placed in a vat or tank containing water, to shrink it. The amount of shrinkage varies, but it is often as much as from two to four yards in a piece originally 50 yards long. The cloth is allowed to lie in the tank for 24 hours, and is then hung on overhead racks to dry. Stepladders should preferably be used to reach the racks, but ordinary ladders are often employed, and in all such cases they should be provided with safety feet to prevent slipping.

The shrinking and drying processes destroy the finish of the goods, and, to restore it, the cloth, after drying, is treated in a press, sheets of cardboard of a special kind being placed between the successive layers. Pressure is then applied by means of hand wheels, and the cloth is allowed to remain in the press for 24 hours. Some kinds of goods require the application of heat as well as pressure to restore the finish, and when this is necessary flat iron plates are heated in a steam-jacketed oven and placed between the layers. A steam pressure of about 30 pounds is necessary to raise the iron plates to the required temperature. The jackets of the heating ovens should be provided with safety-valves to prevent excess pressure, and these should be examined and tested frequently, to make sure that they are in good working order. Care should be exercised in handling the hot plates, not only to guard against burns, but also to avoid dropping them on the feet and thus causing injuries.

In some factories the cloth is removed from the rolls, after it has been examined, and is folded by machines. Operators of folding machines should never try to clean the cloth, nor even to smooth out a creased portion of it, while the machines are running. It pays to avoid accident by stopping the machines. In particular, the cloth should never be touched, for any reason, near the point at which it goes between the rollers; and to afford protection in case this caution is overlooked, there should be a guard in front of the intake rollers, so that the thoughtless workman may not get his finger caught. All exposed belts, pulleys, gears, setscrews, and other dangerous moving parts of the folding machines should also be effectively guarded.

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* The *Travelers Standard*.

In the cutting room the cutters take the paper patterns from the designing room, and mark their outlines upon the cloth with chalk, after which the cloth is cut to the chalked lines by shears or by cutting machines. When shears are used they should always have their points turned away from the workman. Most of the accidents with shears occur when the men are doing close work near the edge of the cloth, as they then have to hold the cloth in order to cut it properly.

In making the lower grades of garments, and in cutting linings, mechanical or electrical cutters are used, and fairly good work can be done with them. The maximum amount of cutting for these machines is about five thicknesses of suiting at one operation. As many as twenty pieces of lining may be cut at one time, however, but the work is apt to be poor when this number is exceeded.

Mechanical and electrical cutting-machines cause many serious injuries, and they should therefore be guarded as effectively as possible. When workmen are cleaning or oiling the cutters they should make sure that it is impossible for the machines to be started accidentally. With electrical machines the plug should be disconnected, and when mechanical belt-shifters are provided these should be locked in the "off" position. Workmen should exercise special care when using the cutters near the edges of the material, as it is here that the great majority of the accidents occur. Shears and other implements should never be left on the cutting tables, when not in use.

In the "making" room the workers specialize in different processes, one being a specialist on basting, another on button-sewing, and another on attaching collars or sewing in pockets or sleeves.

Accidents from the puncturing of operatives' fingers by sewing machine needles are quite frequent, largely because the sewing machines are run at an extremely high speed, particularly on certain classes of work. Some manufacturers use electro-plated needles as a safety precaution, believing that the plated needle is less likely to break, and that if an operative is accidentally pricked, the wound will be cleaner, so that the danger of blood poisoning will be correspondingly diminished. It is still an open question, however, whether or not there is an advantage in using such needles. Special care should be exercised by operatives using the pocket-serging machines, and the Reece and other types of button-hole machines. These run at high speed, and they should always be guarded. There are two or three appropriate and effective forms of guards on the market.

The shafting driving the machines should also be carefully guarded, and under the benches it should be entirely enclosed. Foremen often believe that smooth shafting is not dangerous, but this is a decidedly wrong view, because accidents are very common, from women's hair and dresses being caught by rapidly-revolving shafting, when there are no projections on it whatever. Women working about machinery of any kind should wear nets or caps to confine their hair. Furthermore, they should never do up their hair nor change their clothing in the vicinity of machinery of any kind whatsoever, while it is in motion. The following brief account of a recent accident illustrates very clearly the danger from smooth shafting. The names have been changed for obvious reasons, but otherwise the account is copied verbatim from the newspaper in which it appeared.

"Miss Mary Doe, who was at work yesterday afternoon at a sewing machine in the lace waist factory of Black, White & Co., on the third floor of the twelve-story loft building at Laceville, N. J., reached for her barette, which had dropped to the floor near the revolving shaft which operates a row of sewing machines. As she stooped, her long black hair, loosened by the fall of the barette, fell upon the shaft and was wound about it. In a second she had been dragged to the floor and her scalp torn from her head. Dr. Johnson who arrived in an ambulance from the New York Hospital, found Miss Doe unconscious. She revived as she was being taken to the ambulance, and begged to be taken to her home, where her mother was waiting for her. It was said at the hospital last night that her injuries were very serious and might result in death."

Individual motor-drive is rapidly coming into favor for sewing machines, and is taking the place of the mechanical drive and of electric group-driving. In the individual drive the prime mover is directly attached to the sewing machine, and the energy wasted in friction and otherwise is reduced to a minimum. Moreover, when this method of driving is used the consumption of power ceases as soon as the machine stops.

In the pressing department, specialization is even more pronounced than in the making room, inasmuch as one workman may be skillful in pressing sleeves, while another is better qualified to press collars. Most of the pressing is done by hand, but the thick portions of the garments, where the padding comes, are pressed by a machine which is usually capable of producing a pressure of about 1,500 pounds. The table on which the garment is pressed is kept at a temperature of about 200 deg. Fahr., and the iron is heated to about 350 deg. Fahr.

Hot irons and tables, and all other heated objects or implements, should be well guarded, so that it will be impossible for a workman to get burned. The swinging arms which carry the irons for pressing should also have stop-boards so they will not over-swing and hit or burn other pressmen.

Gas irons are used very commonly for pressing, and care should be exercised to see that the flexible tubing connecting them with the gas supply is kept in good condition, and is not allowed to rest against the hot irons. In some of the pressing operations the pressure of the gas as it is received from the city mains is insufficient to keep the irons at a temperature high enough to permit of continuous work. It then becomes necessary to increase the pressure, and this is accomplished by means of a small compressor which is usually located in the machine room and operated by an electric motor. The pressure should be carefully regulated, and a relief-valve should be connected to the compressor to prevent excess pressure. This relief-valve should be examined and tested frequently, and it should discharge either out of doors or into the suction pipe, to avoid contaminating the air of the workroom.

When electric irons are used, all possible precautions should be taken to avoid electrical shocks and burns. The extension cords should be kept in good condition, and all of the switches, fuses, and other similar equipment should be inspected frequently.

Special study should be given to the subject of ventilation, because the conditions in the workrooms are often highly unsatisfactory in this respect. Ventilation is of vital importance in workshops where clothing is manufactured, on account of the large number of workers in a room. Good ventilation promotes safety, because it tends to keep the faculties of the workers active and normal. Furthermore, the operatives will work at higher efficiency if the workroom is properly ventilated.

Careful supervision should be exercised to see that fire escapes and exits are maintained in good condition. The fire escapes should be kept clear and free from obstructions. If they become coated with frost, ice, or snow, they should be thoroughly cleaned. Exit doors should always open outward, and should be arranged so that they may be easily opened from the inside at any time without the use of a key. Entrances, stairways, and passageways should have a width appropriate to the amount of traffic, and they should be kept free from obstacles, and well-lighted during working hours.

Care should be taken to see that the gas is turned off from all gas irons before leaving the work-place, and that the current is shut off from electric irons. Electric irons may be connected with red incandescent lights that will show when the current is on the irons, and will be extinguished when it is shut off. Scraps of cloth, and waste matter of every other kind, should be collected every day and deposited in metal cans having tightly fitting covers.

It is exceedingly important to have supervisors or foremen at the exit doors on each floor during the two leaving periods of the day, to see that the workers file out in order, because many serious accidents have resulted from trivial and seemingly unimportant causes. The workers should be drilled, so that in the event of a fire or a panic they can be handled effectively and conducted out of the building in safety. They should be divided into squads of about fifty members each, and every squad should be in charge of a designated worker, selected with reference to his coolness and good sense, and the confidence that the other workers have in him. Many serious panics might have been averted, if the workers had been organized in this way and drilled from time to time.

Roofs, when used as places for rest or recreation, should be effectively guarded by railings and toe-boards, and nothing should ever be thrown down from them. The railings should be set about six feet back from the edges of the roofs. Skylights should be protected by frames of stout wire netting, and the skylights and windows should be glazed with wired glass.

The Fixation of Poisons by the Central Nervous System[*]

The subject of the selective affinity between certain poisons and the central nervous system is one that presents many points of interest, with respect not only to general pathology but also to the pathology of the nervous system. A number of observers have pointed out that in various types of intoxication the nervous system contains an amount of toxin greater than any other part of the body. Ogier and Skolosnboff demonstrated the presence of arsenic in the brain in cases of slow intoxication by this drug and the presence of a large amount of hydrocyanic acid in the brain and spinal cord in cases of rapid poisoning by this substance. Similar observations have been made with respect to lead and the anesthetics.

This subject has been approached from the viewpoint of the microbic poisons, particularly those produced by the diphtheria bacillus, in a series of investigations performed by Georges Guillain and Guy Laroche. The results of their studies were first reported five years ago when they described the fixation of the diphtheria toxin by nerve tissue. A comprehensive survey of this subject is presented by these investigators in *Le Progrès Médical*, July 11th, 1914. In their original work they had shown that the medulla oblongata of patients who have died in the course of severe diphtheritic paralysis contains toxic substances that are not present in the case of individuals dying from other affections. The toxicity of the above substances was determined by the fact that emulsions of the medulla oblongata in physiological salt solution when injected into guinea pigs caused the death of these animals. There is a direct path of the diphtheria toxin from the pharynx by way of the nerves to the spinal bulb. The affinity between the diphtheria toxin and the nerves is a particularly close one. Thus these investigators in collaboration with Grigaut showed that if diphtheria toxin is brought into contact with nerve tissue the toxic properties imparted to the latter cannot be removed even after repeated washing with physiological salt solution. It was found that the phosphorized lipoids of the phosphatid group (lecithin, cephalin) have an intense fixing power with respect to this toxin, while the non-phosphorized lipoids, such as cholesterin, are entirely inactive in this respect. Diphtheria toxin when combined with nerve tissue undergoes a marked activation of its toxic properties, the period of inoculation of the experimental disease and the duration of the latter being considerably shortened.

The toxin of tetanus is likewise fixed by the nerve tissues, but is contrasted with the diphtheria toxin in one respect, namely, the nerve tissue of an animal or human being that has succumbed to tetanus, if inoculated into a laboratory animal, will not evoke the disease unless the amount of tetanus toxin present exceeds the amount that has been neutralized by the nerve tissue. Another distinguishing characteristic is the fact that the phosphorized and non-phosphorized lipoids, with the exception of protagon, possess but slight fixing power with respect to this toxin, while the albuminoids are strongly fixative. The clinical differences between diphtheria and tetanus are probably to be explained on the basis of the above differences; the diphtheria toxin which causes paralysis is fixed and activated by the phosphorized lipoids, while the tetanus toxin which evokes muscle spasm is partly fixed and neutralized by the protein substances.

The poisons of the tubercle bacillus are fixed and activated by the nerve tissues. Tuberculin when mixed with nerve tissue has its power increased as much as fourfold. This fact may serve to explain some of the phenomena of tuberculous meningitis. The adult or the child affected with the latter dies before a local defense has been set up. Frequently at autopsy on cases of tuberculous meningitis there are observed but few local lesions; there may be only a congestion of the meninges. The rapidity and intensity with which the convulsive and paralytic symptoms of tuberculous meningitis develop are to be attributed to the avidity with which the poisons of the tubercle bacillus combine with the nerve tissue, particularly in the regions of the medulla and the basal ganglia. It has been shown that in the nerve centers the tubercle bacilli are quickly destroyed. This bacteriolysis which is a mode of defense nevertheless sets free toxins which become more potent by being combined with the cells that are responsible for their liberation.

This subject is one of engrossing interest and eminent clinical importance, and many of its ramifications can only be hinted at. One may allude to the selective affinity of strychnine for the cells of the anterior horns of gray matter of the spinal cord, to the fixation of alcohol by the brain, to the avidity with which chloroform and ether combine with nerve tissue, and to the predominance of lead in the same tissue in cases of plumbism. Oxalic acid is likewise seized by the nerve tissue to a greater extent than by any other part of the body. The symptoms of anaphylaxis are to be attributed largely to the fact that the anaphylatoxins expend their virulence upon the nerve cells with which they combine.

Important from many viewpoints of internal medicine is the hypothesis that endogenous poisons may behave in the same manner as those mentioned above. Nervous symptoms such as paralysis, tremor, convulsions, contractures, delirium, etc., are probably the result of a fixation of toxic bodies by the nerve centers. This is a conception of fundamental significance in psychiatry and deserves extended investigation.

Peat Fuel for Locomotives

The Swedish railway authorities have been investigating pulverized peat as a fuel for locomotives for several years with a view to ascertaining its suitability for various types of locomotives and its cost as compared with coal. One of the locomotives on the State Railway was altered for the purpose, and has been in use for some time in regular working between Stockholm and Upsala with favorable results, both from a technical and an economic point of view.

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[*] Reproduced from the *Medical Record*.

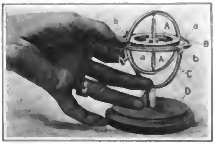

Fig. 1.—Gyro mounted with a Cardan universal joint for demonstrating gyroscopic precession.

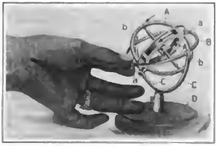

Fig. 2.—Precession carrying the upper end of shaft to the left by tilting the Cardan ring downwardly.

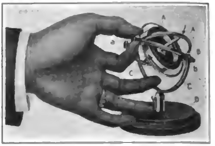

Fig. 3.—Precession carrying the upper end of shaft to the right by tilting the Cardan ring upwardly.

The Electrically-Driven Gyroscope in Marine Work—I*

The Toy of Yesterday Now a Valuable Scientific Instrument

By H. C. Ford

Until a few years ago the gyroscope was little known or heard of except as a child's toy, although as far back as 1852 its action was investigated by the French scientist Foucault, who published the results of his experiments, in which he laid down very clearly the laws of its action.

His first law states that any gyro or spinning body possessed of three degrees of freedom, i. e., free to rotate about a spinning axis and two other axes all normal to each other, will tend to maintain its axis of spinning fixed in space and may therefore be used to show the rotation of the earth. He also demonstrated that when a gyro was given a forced motion of rotation about one of the axes, the gyro would powerfully resist such force while at the same time tending to place its axis of spin in line with or parallel to the axis of the impressed force. This motion, which takes place about an axis at right angles to that of the impressed force, is known as gyroscopic precession, and always occurs in such a manner as to bring the direction of spinning the same as that of the impressed force, and by the shortest path. In other words, if the spinning axis were horizontal and the axis of precession vertical, then the gyro, by virtue of the impressed force of the earth's rotation, would turn about in azimuth and place its axis of spin as far as possible in line with the earth's axis (i. e., upon the meridian) after the manner of a true compass. This strange resisting force with its unexpected motion of precession at a different angle and apparently unrelated to the impressed force, is in reality a simple and logical result of the inertia of the moving mass. Its explanation is well known and follows directly the application of Newton's laws.

It is not, however, the purpose of the writer to go into abstruse theoretical considerations. Suffice it to say that the law of precession explains fully the observed facts with regard to parallelism of the two axes, and is well illustrated in the accompanying figures, Nos. 1, 2, and 3, which show an ordinary gyroscopic top *A* mounted in a Cardan ring *B* by pivots *a*, the outer pivots *b* being supported upon a fork *C* rigidly mounted upon the base *D*. Suppose the wheel with all parts symmetrical, as in Fig. 1, is rotating clockwise, viewed from above, and we grasp the Cardan ring and depress it on axis *b* to position shown in Fig. 2. First it will be found that the Cardan ring is possessed of a quite remarkable amount of rigidity and opposes the forces tending to tilt it. However, as these forces are applied, and though the ring *B* is moved only slightly, yet the gyroscope is seen to immediately swing vigorously through a wide angle upon its axis *a* to the position also shown in Fig. 2. Upon lifting the Cardan ring the gyro will again be seen to swing vigorously in the opposite direction until arrested by the stop as shown in Fig. 3.

For nearly half a century after Foucault had demonstrated its action, the gyroscope was put to no practical use. The late American author and scientist Hopkins, whose writings were published for many years in the Scientific American, was the first to drive a gyroscope electrically. He was able to enlarge on Foucault's experiments and obtain much more persistent results with his continuously driven wheel.

The first serious application of the gyroscope in engineering work was by Obrey, an Austrian naval officer, who made use of the gyroscope to steer torpedoes. About 1903 Dr. Schlick, a German engineer, proposed the use of the gyroscope for stabilizing ships against rolling, and built a number of experimental plants which were tried out with some little success. At about the same time Lewis Brennan brought general public attention to the gyroscope by his announcement of a railroad car that would maintain its equilibrium on a single rail. A car of this type was exhibited in this country in 1910 and the subject of monorail traction was much discussed in the press at the time in connection with the possibilities for high speeds which were claimed for this invention.

Practically all of the serious applications of the gyroscope, and by far the most important of its uses at the present time, have developed in marine work. These are, the steering of torpedoes, the use as a compass, and the use for stabilizing and controlling the motions of ships, the last two of which will be discussed more fully.

Several minor applications have been made, such as (1) stabilizing of various instruments, telescopes, etc., against oscillations when mounted on a rolling ship; (2) stabilizing of a pendulum carrying a pen for recording the angles of roll and pitch of a ship; and (3) stabilizing a horizontal mirror for use as an artificial horizon in taking observations at sea. Some very valuable results have been accomplished along these lines, but the limits of the present paper will not permit of more than a brief mention. Various attempts have also been made to stabilize a body with three degrees of freedom for use in the direct determination of latitude and longitude, but so far as is known, without practical success.

Fig. 4 shows a form of telescope used on board ship for obtaining bearings of distant objects, which has been stabilized by means of gyroscopes so that it is entirely unaffected by motions of the ship in any direction.

Fig. 5 shows one of several types of apparatus which have been constructed for recording the rolling and pitching motion of a ship upon a moving sheet. In the instrument here shown, records of the azimuth as well as various time markings are made simultaneously upon the same record sheet.

Errors are frequently introduced in navigation when measuring the altitude of a heavenly body above a false horizon caused by mist or by the mirage effect of the heated air on a tropical sea. Very frequent observations of the sun or heavenly bodies could be taken were it not that the horizon is obscured by low-lying banks of fog or darkness.

Fig. 6 illustrates a gyroscopic artificial horizon which provides a means for eliminating these errors in observation and makes it possible to measure accurately the altitude of any heavenly body that can be seen, whether or not the horizon is obscured.

The automobile torpedo, as is well known, depends upon a gyro steering gear for its directive power, and would, in fact, be utterly ineffective for its purpose without such a device. The importance of the torpedo in warfare is of course recognized, so that the great value of this application of the gyro needs no further comment.

The gyro compass shown in Fig. 7 is depended upon for use under battle conditions where the magnetic compass could not possibly be employed, due to the large masses of magnetic material constantly being moved about in proximity to the compass. As an instrument of navigation, the gyro compass has also proved of great accuracy and value in enabling the ship to be held steadily upon its course irrespective of wind, sky, or sea. The foreign navies are also rapidly adopting the gyro compass, and it seems certain that its use on all of the larger steamships and ocean liners will be found in a few years when its great advantages have become more widely known.

The very high development of the gyro compass during the past few years has been largely due to the efforts of a pioneer in the electrical art, Mr. Elmer A. Sperry, whose long and interesting experience with gyroscopic phenomena and belief in their engineering possibilities led him to devote practically all of his time to its development.

It has been the privilege of the writer to be associated with Mr. Sperry for several years past in this work, during which time a plant has been organized and equipped for the design and manufacture of many forms of gyroscopic apparatus.

A number of workers abroad have also been laboring with great persistence and some degree of success to

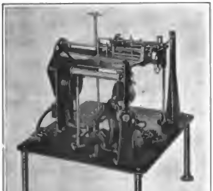

Fig. 5.—Instrument for recording the rolling, pitching, and yawing of vessels.

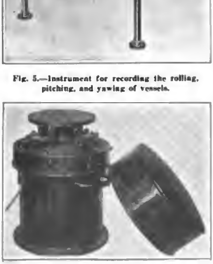

Fig. 6.—Gyroscopic artificial horizon.

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* Paper read before the American Institute of Electrical Engineers and published in the *Proceedings* of the Institute, vol. 33, No. 6, p. 873. Copyright, 1914, by American Institute of Electrical Engineers.

solve the many physical problems involved in translating the idea of Foucault into concrete terms of steel and bronze which will function under the extremely severe conditions on shipboard.

The nature of the problem is indicated when one realizes that the gyro compass is so sensitive that it responds instantly and with the highest degree of accuracy to the very slowly impressed angular motion in space about the earth's axis four thousand miles distant, while at the same time it remains indifferent to the angular movements of the ship several hundred times greater in intensity.

In view of the expensive use of the gyro compass and the nature of the problems involved in its development, it may be of interest to look into the theory of its action somewhat briefly and then to note some of the many special construction details and various electrical devices employed in this highly organized instrument.

Fig. 8 shows a small device which may be used to demonstrate the action of precession in the gyro compass. In this device we have a small disk marked with the cardinal points to represent a compass card and mounted upon a ring swiveled to rotate on a vertical axis within a hand-supporting frame. The ring carries a wheel which spins upon a horizontal axis fixed in the ring parallel to the N-S line of the compass card. If the device is held extended in the hand while the demonstrator turns slowly on his heel toward the left, we may consider his body as the axis of an imaginary earth and his head as the virtual north pole, since his rotation would always be easterly.

If the device is extended with the axis of the card perpendicular to the body at the waist line, the compass may be considered as located approximately at the equator. If held opposite the shoulder, with the axis of the compass card or handle making an angle of 45 degrees with the body, the compass would be represented in operation at latitude 45 degrees north.

Now when the wheel has been made to spin in a clockwise direction viewed from the south side of the card, if the device is carried about in the hand as above, the card will immediately orientate or turn on its axis to bring the north side toward the virtual north pole.

If the demonstrator should reverse his direction of rotation and turn toward the right, which would now represent east, we should have to consider that the north pole had been shifted to his feet, and if the little model is a true compass it should also reverse its direction and point to the new pole. This is what actually occurs, for the gyro compass not only holds to the meridian when placed thereon, but is actually possessed of a powerful north-seeking tendency many times greater than that of the magnetic needle.

The above demonstrates the elementary action of the gyro compass on an imaginary earth, the length of whose day is about twenty-four seconds. Under such conditions this little compass is ideal in its simplicity.

When, however, we are considering an instrument of precision, for actual use on a ship rolling, pitching, and yawing in a heavy sea, or maneuvering at various speeds in every possible direction, the matter of picking out this demonstrator who will keep his body parallel to the earth's axis under such conditions and rescue a struggling directive force from the waves, is a somewhat larger contract.

As a matter of fact, many and serious are the mechanical and theoretical problems which had to be solved in producing a practical compass for navigation. For example, when mounted on a ship steaming rapidly north, say, the gyro axis does not point true north, but has a certain deflection, for the reason that the actual motion in space is no longer due easterly, but is about a resultant axis somewhat to the westward of the earth's axis. The amount of this deflection, which is a variable, depending upon the speed, course, and latitude of the ship, has been exactly determined for all conditions.

In the Sperry compass a device is employed which corrects for the above factors and automatically introduces this correction into the compass readings, which are therefore always made accurately upon the meridian. Other special mechanical devices are employed for the following purposes, among others:

(a) To provide a substantial mounting for the gyro element with the highest degree of sensitiveness.

(b) To damp oscillations in azimuth.

(c) To compensate various acceleration pressures.

(d) To prevent errors caused by retardation of the wheel.

(e) To set the compass quickly on the meridian even when the direction is unknown.

(f) To prevent errors due to persistent oscillations in certain oblique planes.

(g) To admit of determining the speed of the wheel by observation.

Space will not permit of a further study of the many theoretical problems involved nor of a detailed description of all the mechanical devices employed in this solution.

The general arrangement of parts constituting the Sperry gyro compass is shown in Fig. 9, which for greater clearness in illustrating the various functions has been simplified by the omission of electrical circuits and minor details.

The gyroscope wheel is mounted to rotate on a horizontal shaft *A* within the casing *B*, which is pivoted on the horizontal axis *C* through its center of gravity and carried by the frame or vertical ring *D*.

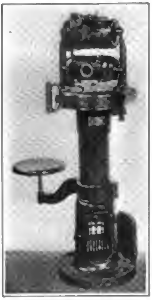


Fig. 4.—Telescope stabilized by gyros.

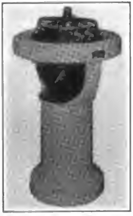


Fig. 7.—Master compass with covers removed.

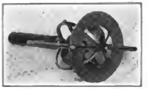


Fig. 8.—Model for demonstrating the action of the gyro compass.

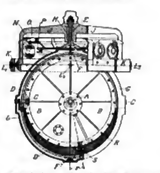


Fig. 9.—Method of mounting the directive element.

The ring *D* is suspended by a torsionless strand *E* and guided by bearings *F* and *F'* to allow a free oscillation of limited amount about its vertical axis within the frame or "phantom" *G*, so called because of its characteristic action as a "shadow" in following up each motion of the ring *D*. The phantom *G* has a hollow stem *H* to which the strand *E* is attached at its upper end, and the stem forms a journal for rotation in azimuth with respect to the supporting base frame *J*.

The frame *J* is mounted to swing in the binnacle by the usual Cardan suspension, consisting of the ring *K* and suitable bearings *L1*, *L2*, *L3*, and *L4*, the last not shown.

The frame *J* carries a "follow-up" motor *M*, driving a master gear *N*, forming a rigid part of the phantom *G*, whereby the latter is positively driven in azimuth to respond to any movement of ring *D*.

The ring *D*, which with the wheel casing is termed the "element," carries a pair of electrical contacts in the form of trolley wheels, which co-operate with stationary contacts mounted upon the phantom *G* for the purpose of controlling the follow-up motor *M*, the electrical connections not being shown in the figure.

The power-driven phantom *G* is thus automatically controlled so as to respond instantly to all movements of the sensitive element, and in fact to all relative movement in azimuth between the ship and the gyro.

This characteristic of the phantom enables it to be used for various important functions, namely, to carry the scale or card *O* and a cam *P* forming part of the automatic correcting device. The power drive is also utilized in operating the transmitter for the repeater instruments, and in overcoming friction of the slip rings needed to carry current to the gyro.

Since the phantom *G*, though at all times rigidly anchored to the binnacle, stands in practically constant relation to the sensitive element as regards motion about the vertical axis, but is nevertheless entirely separate therefrom, it serves as an anchorage for producing stresses to restrain and correct the movements of the sensitive element. This is accomplished by means of a yielding connection between the phantom *G* and the gyro case *B*, in the form of a pendulum or bail *R*, supported by and forming a part of the phantom. The point of attachment *S* to the gyro casing is located in a certain position eccentric to both the vertical and horizontal axes of the gyro. By this means several most important results are obtained, including positive orientation and the prevention of oscillation.

The complete electrical equipment of the compass system which will now be considered comprises:

1. A voltage regulator of special design.
2. A three-phase alternating-current generating set.
3. A 20-volt direct-current generating set.
4. A direct-current emergency service.
5. An alarm system.
6. An automatic control and protective system.
7. Specially designed controlling switches.
8. The gyro motor.
9. A servo motor or follow-up system.
10. A secondary transmitting and receiving system.

Fig. 10 illustrates the various parts of the Sperry gyro compass system for use on a battleship. The master compass and controlling apparatus are installed in a protected portion of the ship behind heavy armor. The repeater compasses are mounted at various points about the ship at the different steering stations. On a battleship, for instance, repeaters are supplied at the main steering platform, others on the bridge for taking bearings, one in the conning tower for steering during battle, one in the steering engine room at the stern of the ship, and in some cases one or more additional repeaters in ships provided with additional steering stations.

The compass is also used in connection with various other instruments for obtaining and recording various data.

(To be concluded.)

Heavier Rails for Railways

It is apparent that the rapidly increasing weights of both locomotives and loaded cars of all descriptions will soon make a heavier rail necessary. Rails weighing 110 pounds per yard have already been introduced on the Lehigh Valley road on heavy grades and sharp curves, and now the Pennsylvania Railway is trying a rail that weighs 120 pounds, which is far in excess of the 100-pound rail that, with few exceptions, has been the heaviest heretofore used. The new Pennsylvania rail has 41 per cent of the material in the head, 22 in the web, and 37 in the base. The sides of the head have been given the steep slope of 8 degrees and the top has the short radius of 10 inches, the corner radii being $\frac{7}{16}$ inch. The fishing angle under the head is one of 18 degrees, and above the base one of 13 degrees. The height is 6¾ inches.

The Origin of Waves[*]

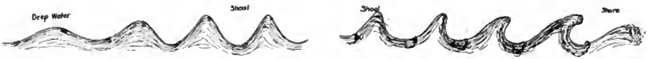
Their Propagation and Their Force

By Edgar De Geoffroy

RUDYARD KIPLING, in his description of "The Ship that Found Herself," says:

"As soon as she met the lift of the open water, she naturally began to talk. If you lay your ear to the side of the cabin the next time you are in a steamer, you will hear hundreds of little voices in every direction, thrilling and buzzing, and whispering and popping, and gurgling and sobbing and squeaking, exactly like a telephone in a thunderstorm."

All these complaints which rise from the very bowels of a ship are signs of the fatigue and labor of the material entering into her intimate structure, under the efforts of the waves.



Influence of depth of water on shape of waves.

Those deep wrinkles, which at certain times overspread the mobile physiognomy of the ocean, are of great variety, and hence produce various effects upon a vessel. Sometimes short and crowded, the liquid undulations that beat upon her seem, with their limited dimensions, devoid of danger; but on the contrary their disheveled crests, their steep flanks, betoken the fury of the "breaker." Again, long and majestic, they seem of alarming size; but their rounded summits and gentle slopes rob them of the violence of the shorter type of wave, and the ship rises easily as they sweep beneath her.

These ridges on the surface of the water arise as the result of two causes, one artificial and one natural. The former is the movement of the ship; the latter the friction of the wind. The vessel's prow, cleaving the water, pushes it aside to right and to left, and the liquid thus suddenly displaced vibrates and oscillates with the shock, giving rise to the billowy waves at the bow of the ship. The more violent the rupture of equilibrium—*i. e.*, the faster the movement of the ship—the more powerful will be these waves. They gradually fade out in "echoes" as they recede from the vessel, but they never cease to accompany her, and, by their lifting motion, to offer more or less impediment to her progress.

But the principal cause of waves, and the one most fraught with danger, is the wind. Before you lies a dormant sheet of water, flashing in the sun and seeming perfectly still; but bend over this mirror-like surface with a magnifying glass, and you will be surprised to discover myriads of minute dimples—infinitesimal vortices, miniature cyclones, showing that evaporation never ceases—a fact further evidenced by the clouds floating overhead.

As the wind rises and the aeration of the surface goes on at a more rapid rate, evaporation increases; the surface of the water becomes honeycombed with little hollows, ever more numerous, offering a greater hold to the moving air. In the midst of these asperities each particle of water pushed by the wind tends to override the one in front of it. Moving across, it will find itself sheltered from the frictional impulse of the air and will return in a downward course toward its original position, seeking to fill the vacancy which its displacement had caused. Thus it will have described a tiny orbit, analogous to those of the heavenly bodies.

The majestic swell of the ocean which, after the wind has fallen, continues to sweep toward the horizon in broad furrows and rounded crests; this swell which is the continuation, in virtue of inertia, of the movement given to the heavy masses of salt water by the tempest, and which grows regular as it gradually subsides, teems with little orbital movements of the water-drops. From the surface down to a certain depth, each liquid particle describes incessantly, in its place, a little closed curve.

Imagine a wheel moving along the ceiling of your room and beside a wall, in such a manner that a nail transfixing one of the spokes scratches the wall with its point. The resulting curve will represent the profile of a wave. If the wheel revolved without advancing, the nail would describe a circular orbit; it would then represent a particle of water oscillating in its place. If, on the other hand, the wheel advances, the nail traces the outline of a series of droplets, a chain or thread of water, all the particles of which were in the same horizontal plane when in a state of repose. The distance separating two summits or crests of the undulation is called the wave-length; half a wave-length is therefore the horizontal distance from a crest to a hollow. The height of the wave is the vertical elevation of a crest above the next hollow.

The undulation is not, however, stationary. It runs along the water like the undulation of a rope which, when lying on the ground, has had a violent up-and-down motion given to one of its ends. Yet the water itself remains in place, alternately rising and falling, as may be readily seen from the movement of a floating cork or of a swimming bird, which seems to defy the waves as it rides upon them. Suppose you examine the profile of a wave during a very brief interval of time, as, for example, during a flash of lightning. It will appear motionless, like the trace made by the wheel on the wall of your room. After a brief disappearance you see it reappear by the fugitive light of another flash, but not in the same place; it has moved horizontally. Without quitting their orbits, the water particles of the liquid chain have all revolved through the same angle at the same time; consequently, at the end of a certain interval, when all the particles have described a semicircle, the wave-crests will be replaced by hollows and the hollows by crests. When the whole orbit has been described, the waves will have advanced their own length, and their profile will appear unaltered, but in reality each hollow will have replaced the next hollow, and each crest the next crest. All these regular undulatory forms are really *limiting* forms, attained only when the wind which lifts the waves has subsided.

We have seen how the water is set in motion when the wind first blows upon its tranquil surface. First appear mere wrinkles—the effect of what sailors call "cat's-paws." The impulse of the air which drives the liquid particles from their position of repose is not of the same intensity at all points; local variations determine the inequality of these wrinkles, which, growing larger, become waves. The larger waves offer more surface to the wind than the smaller, move more rapidly than the latter, overtake and absorb them, and thus swell more and more, growing at the expense of those ahead of them. However, on the windward slopes of these large waves other undulations continue to form by the same process as on a tranquil surface. These secondary undulations are slower in movement than the waves on which they arise, because they are smaller; hence, as soon as they form, they begin to lag behind the general movement, separate from the mother wave, and are gradually overtaken by the wave following, which absorbs them. It is for this reason that, in a stormy sea, you will sometimes see two or three nearly regular waves, of the same duration of passage, followed by a great wave of longer duration, and again by smaller and more regular waves.

If the wind suddenly shifts there is veritable chaos. The waves spring up at random, without apparent cause, and are torn into spray by the fury of the blast sweeping in a direction opposed to their previous motion. There is a shock and a struggle between the waves pressing forward with the momentum of their previous course and the wind driving them back, while the foaming sea seems to be beside itself with rage at this sudden resistance.

If the wind dies down, the disorder gradually disappears and each system of "choppy" waves becomes a system of swells, and these swells react on one another, as above explained. The discord lasts until the moment when, as if under the invisible baton of the leader of a vast orchestra, a single note or measure prevails, and all others blend into it. The phenomenon becomes a har-

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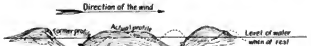
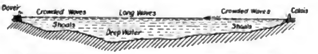
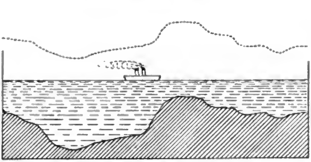
[*] Translated for the SCIENTIFIC AMERICAN SUPPLEMENT.



Absorption of small waves by larger ones.

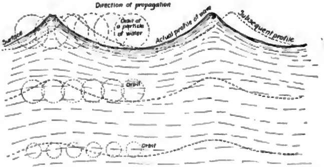


The profile of the bottom affects the speed of steamers crossing the English Channel.



Influence of a submarine ridge on the progress of a ship.

The dotted curve shows the variation in the height of the waves produced by the vessel. The shallower the water, the higher the waves and the greater the resistance they offer to the advance of the ship.

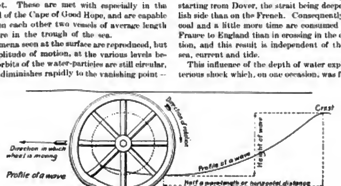


Orbits of water-particles and profiles of waves at different depths. The movement of the surface is repeated below, but with diminishing amplitude.

mony, and the beautiful ocean swell, slow, majestic, and regular, presents itself for our admiration.

The highest waves ever observed attained heights of 40 to 45 feet. These are met with especially in the neighborhood of the Cape of Good Hope, and are capable of hiding from each other two vessels of average length when both are in the trough of the sea.

The phenomena seen at the surface are reproduced, but with less amplitude of motion, at the various levels beneath. The orbits of the water-particles are still circular, but their size diminishes rapidly to the vanishing point—a state of absolute repose. The depth beneath which the awful silence and calm of the submarine abysses prevail is not always the same. It depends upon, and increases with, the amount of agitation at the surface. In general, on descending to a depth equal to half the length of the waves we find orbits not more than a hundredth as great as at the surface, i. e., the beginning of comparative calm. Below an average swell, say, 300 feet from crest to crest and 10 feet in height, at a depth of 150 feet the oscillations are not much over an inch in extent, and the motion is therefore insignificant.


Direction in which wheel is moving
Profile of a wave
Direction of rotation
Crest
Height of wave
Profile of a wave
Half a wavelength or horizontal distance from crest to trough

Imagine a wheel moving along the ceiling of a room; the point of a nail, passing through one of the spokes, will trace a curve on the wall exactly like the profile of a wave.

If the sea-bottom is near the surface, the mechanism of the waves will be profoundly modified. Moreover, the bottom will undergo erosion, an examination of which will serve to determine the depths reached by the movements of the water. Thus, at Cherbourg, in rough weather, it is necessary to descend to more than 25 feet beneath the trough of the waves before one finds the bottom undisturbed. On the coasts of Algeria, pure sand is not disturbed below a level of 50 feet, while muddy (i. e., finer) sand is not disturbed below 100 feet. In the open sea, light sands are moved at a depth of 130 feet in the English Channel, 160 feet in the Mediterranean, and as much as 650 feet in the ocean. These depths, which appear enormous, are really trifling in comparison with the abysses of 2,000 fathoms which have been measured in the Mediterranean, and those of 4,000 to 5,000 fathoms found in the ocean.

As these figures show, the depth to which the disturbance extends from the surface increases with the depth of the sea. This relation is connected with the fact that closed seas, such as the Mediterranean, the Black Sea and the Caspian, have waves of less length and height than the ocean, with its unlimited horizons and swells of enormous dimensions. The reason is that, as we have already seen, the length of the waves and the depth of sensible disturbance depend upon each other, and throughout the greater part of these closed seas the depth at which all disturbance must cease finds itself limited by the presence of the bottom, which allows the water-particles only to move to-and-fro, scraping the ground. This forced abridgement of the depth of sensible disturbance also limits the wave-length. While in deep water, with nothing to hamper its motion, the latter is large and free, the swell long, the waves far apart, very round, and relatively low; over shoals, on the contrary, the movement appears pressed together horizontally; the wave-length diminishes; the comparative height of the waves appears to increase, though in reality it decreases, but less rapidly than the length, so that the hollows become more pronounced, the slopes steeper, and the crests more pointed. If the bottom gradually rises, the progress of the base of the wave is retarded by the friction of the ground, while the crest preserves its original motion. Thus there is a tendency to lean to one side until finally the summit topples over, and, losing the sharpness of its contour, becomes fringed with foam. Then, in a bubbling and frothy mass, the wave "breaks." This correlation between the depth of the water on the one hand, and the length, height, and velocity of the waves on the other, is so intimate that, when waves are produced by the motion of a vessel, the latter's advance shows the influence of the profile of the sea-bottom.

The faster a vessel travels, the farther apart are the waves she produces; they move freely away from the hull and offer less impediment to her progress. On the other hand, the more slowly she travels, the more crowded will be the waves, and the motion of the vessel will be proportionately impeded. Navigation at high speed is, however, laborious in shoal water for the reason that the long waves produced are out of proportion to their possible depth, as limited by the bottom. Thus in crossing the Channel, a steamer starting from Calais finds it more difficult to attain and maintain her full speed than one starting from Dover, the strait being deeper on the English side than on the French. Consequently, a little more coal and a little more time are consumed in going from France to England than in crossing in the opposite direction, and this result is independent of the state of the sea, current and tide.

This influence of the depth of water explains the mysterious shock which, on one occasion, was felt by a vessel passing at full speed over a submarine ridge. One would have said that she had collided with some floating obstacle; the number of turns of the screw suddenly diminished, as if the water had all at once become more viscous and hence more difficult to push aside. If, before and after this happened, it had occurred to someone to observe from moment to moment the height of the waves, it would have been seen that their uninterrupted succession reproduced above water a profile suggesting a slightly distorted image of the contour of the bottom over which the vessel was passing.

What mariners dread most, however, is not these phenomena of more or less moderate violence, which are observed even in fine weather, but the breakers or surf which occur in shoal water during a storm. Here we have to do with forces wrought to a frenzy—condensed, concentrated, so to speak, in a relatively shallow layer of water, and hence more violent in their reaction.

The force of the waves is proportional to their length, and to the square of their height. Thus while, with a given height, a wave 300 feet long has twice the force of one 150 feet long, with a given length, a wave 20 feet high will have four times the force of a wave 10 feet high. In other words, it is the height of the waves that is the most redoubtable feature of a stormy sea. Hence the lofty, toppling breakers are most to be dreaded in navigation. In the Indian Ocean, these may be met with nearly four miles off-shore, and in water 50 deep feet.

Let us try to form an idea of the force of a relatively moderate wave 300 feet long and 10 feet high. On its gliding, undulating surface let us imagine a little section 3 feet square. Do you know what the energy stored up in this small space is capable of doing? It is able to hurl a mass of two pounds nearly three quarters of a mile into the air. If the height of the wave is doubled, its force becomes increased four times. Think, then, what its violence will be when it breaks. When we remember that the area of the sides of a ship may be more than 5,000 times as great as the little surface we have just been considering we will see with what care it is necessary to study, not only the shape of the vessel's hull and her general structure, but also the nature and mode of assemblage of even her smallest parts.

Dead Men Do Tell Tales*

By Davias Waterson

Once upon a time many a murderer was acquitted and many an innocent man hanged, because, to all appearances, they had or had not, been guilty of the crime.

But to-day an assassin has to reckon with the physicist, the chemist and the Rontgenologist, who start off on his track and force him to face damning, dispassionate scientific facts, but, with equal zeal bring these facts to clear a miserable man protesting his innocence, yet condemned beforehand by circumstantial evidence. Now, if a man is found walking quickly away from the place where a body has been found, and if the man has blood stains on him and on his pocket knife, naturally he is the murderer, so why spend a fee on an expert to prove the contrary?

Just such a case occurred in France. It was no use the man saying he had poached a rabbit, made a stew and burnt the skin and bones to avoid possible detection. He was condemned because the bloodstains and a known hatred for the victim shouted guilty! Then came along a physicist and showed the blood to be that of a rabbit, for, by the unique methods of two professors, E. T. Reichert and A. P. Brown, it can be determined to what species of animal, bird or reptile the blood belongs, since every species has distinct crystallization. Experts claim to distinguish differences of nationality and it is no illogical optimism to state that their claim to prove consanguinity may prove to be correct. If Jacob had been able to set a scientist to work on Joseph's coat the brethren would have been confounded, and Reuben, the conniver at deliverance, extra triumphant. Ever since those days the malignant have tried to fix guilt on innocency by spattering the blood of animals on clothes or weapons, but it never can happen again in civilized countries.

A little while ago a mother murdered her little girl in a lonely spot and "murder by person or persons unknown" was the verdict. A suspicious neighbor, who disliked the woman, took up the search privately and one day found a blood-stained knife near the house. "Why, that's the knife I used to kill a rabbit last week. I put it there in the wall meaning to clean it," cried the mother.

Submitted to an expert, the knife told of human blood, blood shed a year ago, and the terrified mother confessed her guilt. It is now over seven years since an Italian physicist, A. Lechanarzo, perfected the method of determining the age of a bloodspot. Would Rizzio's blood, said to be renewed every year on the floor of Holyrod Palace, stand an investigation? I think the tourist, enjoying the induced thrill of horror, would rather the scientist kept out of the way!

Mutilation of a body is not always effectual, and has occasionally, by its very dexterity, convicted the real offender. A murderous butcher will, naturally, cut up his victim with precision, and a medical student or surgeon would do it in a skillful fashion. The mutilations by Jack the Ripper showed him to have considerable anatomical knowledge.

A physical defect, engendered by disease or habit, often guides an expert in detection, but when a man cuts his old father into 130 pieces and buries these separately in garden and field he naturally expects to lull suspicion, especially when he daily expresses surprise that the aged parent does not return from Paris.

Six months after the deed a farm hand dug up a hand, no clue apparently, except that a friend, a medico-legal expert, took note of certain callosities in the palm, rather peculiar ones, and soon after begged of the son his father's stick as a memento. The curiously carved knob exactly fitted the skeleton hand and the son was convicted of the murder. In the same way the body of a mutilated nun was identified by the callosities on the knees produced by constant kneeling; and Sir William Fergusson proved the identity of Livingstone (though it was hardly doubted) by showing an old ununited fracture in the left humerus. The structural deformations induced by occupation, often lead to the identification of a murdered man when he has been, say, a tailor, a barber or a shoemaker, while the condition of the teeth may show the victim to have been a printer or a potter, owing to the plumbism engendered.

Now, if a man is found shot through the head and with a pistol in his hand, what more rational than a verdict of suicide? But in real suicide the weapon is held so firmly that force is required to dislodge it. It seems as if the muscular spasm persists until rigor mortis occurs and sets it. Several experts have tried to make the hand of a corpse grip a weapon, but have never succeeded and their knowledge of this fact has often opened the avenue to detection of murder. Again, if you found your grandfather on the floor with a rope round his neck and the other end dangling from a nail in the wall, certainly you would say that he had hanged himself and his weight had broken the rope.

But the medico-legalist is as well up in knots as a sailor and knows a suicide will tie them one way, a murderer another. There was a case in Paris of a grandfather who had, apparently, hung himself in the manner described. But he had not tied the rope, declared the expert, and, in face of such uncanny knowledge, two neighbors confessed they had from their window seen the son-in-law strangle his father and arrange the other piece of rope.

A would-be murderer might advantageously study physiology, i. e., the physiological action of certain substances on the human body and might also, if he intends hiding the corpse, read concerning flora and fauna in the dead. The advice of Moquin-Tandon, sometime professor of Natural History in Paris University, was often asked by legal doctors because he had made a special study of the latter. The body of a little girl was found tightly packed up in a soap box, and the mother, when found in another city, tried to fix the crime on a friend and as happening two months ago. It was then the end of July. By a careful study of the flies and larvæ found in the remains, the expert proved the body to have been in the box since the preceding February and the mother confessed to having killed the child on February 27th. In the same way the examination of the larvæ on the body of a child hidden up a chimney proved death to have taken place fully two years previously, and this verdict led to the acquittal of a suspected person. There are certain fauna which begin their work soon after death, then disappear to give place to others, but the succession is invariable and marks time for the scientist.

The different physiologic action of fire on a dead body and a living one was not known by the man who rushed frantically to his neighbors, saying he had found his wife lying across a chair by the fire badly burned from waist to knees and also on the neck. Unfortunately for him the doctor pointed out that burns made before death contained serum and there was no vesication (thin serous fluid under the skin), moreover, the fire could not have passed from waist to throat. The man then confessed to strangling his wife and afterwards setting fire to her.

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* The Alienist and Neurologist.

The student who murdered his aged uncle by drowning had clearly not taken chemistry in his studies or he would not have been so confounded when brought to justice. He had wound nine yards of thick lead tubing round the body to sink it. Surely enough? But a little knowledge of chemistry would have made him make a few incisions for the escape of natural gases, as these brought up the corpse in spite of the heavy weight.

Lynx-eyed Science is rendering it ever more difficult to dispose of a body or hide the crime of murder. Human blood and hair and bones have characteristics distinctly their own. The "gory knife" of melodrama is no longer sufficient to fix a crime, and even if, as seems possible, the penny novelettist should kill his hero with radium, why, the physicist would come along with the electroscope and with it absolutely refute or confirm the accusation.

Rubber Roads a Future Possibility

The connection between rubber and engineering is closer than the casual observer might suspect. It is safe to say that if rubber were deleted from the list of materials used in engineering work many phases of the industry would come to a standstill.

The first stoppage that would occur would be in connection with the manufacture of electrical plants. There is nothing to surpass rubber as an insulating material, and thousands of tons of rubber are used annually for this purpose in cable construction and in the production of electrical machinery of all kinds.

The road engineer of the future is a still bigger potential user of rubber, however, than the permanent way engineer. Rubber roads, though they may not be immediately practicable, are almost certain of ultimate adoption. But before the rubber road "arrives" a great deal of "missionary" work has to be done. At present engineers responsible for the upkeep of our roads fight shy of the rubber road proposition. Though it may be possible to calculate what a rubber road will cost, there is no definite and authoritative information available as to how long such a road will last under varying climatic conditions. It is useless to expect a local or other authority to consent to the laying down of stretches of rubber road at $25 per square yard unless they are quite convinced of the life that they may reasonably expect to get out of the road.

It is for the purpose of obtaining such information as will be required by road engineers that the Rubber Growers' Association has made a free grant of 1,000 tons of plantation rubber and has offered an additional 1,000 tons at the nominal price of 25 cents per pound during the next five years. The rubber will be used in the first instance on difficult roads in order definitely to ascertain its merits.

Already the association has taken practical action by awarding its gold medal to Mr. M. M. Dessau for his successful piece of experimental rubber roadway as laid down in the Old Kent Road. In Mr. Dessau's system jarrah wood blocks are used with a surface cushion of rubber, held tightly in position by dovetailing. The blocks are readily movable, an advantage in these days of frequent subterranean excavations by electricity, gas, water, telephone, telegraph, hydraulic power, and other corporations. They interlock perfectly and give an absolutely water-tight joint such as cannot conveniently be obtained in any other way. This prevents the ingress of moisture and the consequent damaging of the road foundations.

It is claimed that the latter do not require to be nearly so strong in the case of rubber roads as with ordinary wood blocks. The reason is that the vibration of the heavy traffic on the latter causes the concrete foundations to disintegrate even if the thickness of the concrete is in excess of the now frequently adopted 12-inch standard.

The fact that thinner foundations can be used with rubber roads can be set against the extra cost of the rubber blocks, though even then the costs will not be equal, but the life of the rubber road may be expected to be so much greater as to more than compensate for the extra cost, apart from the advantages of silence and the prevention of skidding and side-slip of vehicles. The latter claim may at first sight appear a somewhat remarkable one, but it is a fact that the rubber road sections that have already been laid have proved to be most effective "non-skids." Even when covered with oil, or when blackleaded, the rubber road does not appear to cause motor vehicles to slip. This was hardly expected when the first sections were laid down. In fact, so convinced were insurance experts that the risk of disaster through side-slip on rubber roads was enormous that they quoted absolutely prohibitive rates when one section was being laid down, and a guarantee had to be given to the local authority. Now the premium is just the same as would be the case for any other road; in fact it is no longer necessary to insure. Here is a case of "the proof of the pudding," to be sure. And further proof will be forthcoming in due course as to the lasting quality of the rubber road.

The section in the Old Kent Road, after carrying for 205 days some of the heaviest traffic in London, amounting to ninety tons per square foot per hour for twenty-four hours, was not perceptibly worn, whereas an adjacent 4-inch wood block lost ½ inch in thickness in the same time under the same load.

Besides the South London experiments, trials are shortly to take place actually in the city. The corporation has granted the necessary permission to the acting agent of the Federated Malay States government to lay down a section of rubber roadway in Cannon Street, E.C., where the traffic is very heavy, and where its effect on the road can conveniently be observed by all interested in this new development.

There are clearly great possibilities in front of the rubber road, and as soon as its merits have been conclusively proved and accepted we should be within a reasonable distance, if not of the universal rubber highway, at least of the rubber road for special traffic conditions, with a resulting consumption of raw material that should make all rubber shareholders rejoice.—*The Daily Telegraph.*

Aircraft in War

The decisive influence of reconnaissance by aircraft has already made itself felt during these stages of the war. Within a week of the outbreak of hostilities the French general staff possessed definite and accurate information regarding the exact position of every single army corps massed along the German western frontier and occupying Belgium.

Apart from the general effect exerted upon the conduct of hostilities by aircraft—an effect which cannot yet be precisely estimated, although its influence is already perceptible—several specific instances of the useful employment of aeroplanes have been reported. Events have proved that rifle fire is largely ineffective against aeroplanes, which, traveling swiftly, offer a very difficult target; the planes may be struck repeatedly by bullets, but, unless hit in a vital spot, such as the engine or the propeller, an aeroplane, even though riddled with shot, could continue its journey with its efficiency scarcely impaired.

With shell fire the case is different; a fragment of a shell striking an aeroplane would, in the majority of cases, inflict irreparable damage and bring it down to earth. On the other hand, an aeroplane traveling at a great height and moving at sixty miles an hour or more forms a most elusive target, and it is only when the necessity for detailed observation causes the pilot to fly low that the ordinary artillery, incapable of high angle fire, has a reasonable chance of bringing an aeroplane down. Experience has shown that an aeroplane pilot can only make accurate observations of the movements and positions of troops from a height not exceeding 4,000 feet, at which altitude it is within range both of rifle and shell.

The official statement that a French aeroplane reconnoitering over German territory in the Lorraine region was pursued by two German machines, but succeeded in escaping, and returned safely to the French lines, is interesting in that it proves that the light, fast French aeroplanes can without difficulty elude the more ponderous and slower German machines.

The bombardment of the fortress of Vesoul and the town of Lure by a German aeroplane confirms the opinion generally held by experts that the small bombs which alone can be carried on an aeroplane are incapable of doing serious damage. In each case the railway station formed the target, and was repeatedly struck, but the damage done was only slight and easily repaired. No aeroplane carries a flag, but the French machines bear on the underside of each wing a large Tricolor formed of concentric circles, in order that they may be identified and not fired upon by their own troops.—*The Daily Telegraph.*

Earthquakes and the Phases of the Moon

No regular periodicity of earthquakes has yet been demonstrated. The Italian seismologist, Cancani, thought that the great earthquakes of the Adriatic region recurred at intervals of one hundred years, but Agamennone and Cavasino proved, by a more critical examination of the records, that this supposed regularity does not exist.

In Japan the frequency of earthquakes has not varied in seven centuries. The earthquake statistics for the entire world since 1860 show that the number of destructive shocks (megaseisms) has remained nearly constant, at about thirty-one per year. From Milne's catalogue of megaseisms Montessus de Ballore has proved that the frequency of earthquakes bears no relation to the seasons or to the dry and rainy periods determined by Brueckner.

Dr. Otto Klotz, of the observatory of Ottawa, Canada, has classified in accordance with the phases of the moon the 405 shocks recorded at Ottawa from April, 1908 to December, 1913. He finds that, of each 100 earthquakes, 26.2 occurred at new moon, 23.0 in the first quarter, 22.4 at full moon, and 28.4 in the last quarter.

The differences in earthquake frequency in the four phases are considerable, but a much larger and more extended mass of concordant statistics would be required to prove the existence of a physical relation between earthquakes and the phases of the moon.—*Cosmos.*

A Correction

It has been called to our attention that the name of one of the authors of the article on "Experimental Plotting of Electro-static Fields" on page 216 of the issue of October 3rd, was wrongly spelled Querbacker, when it should have been S. H. Ouerbacker. The error was caused by illegibility.

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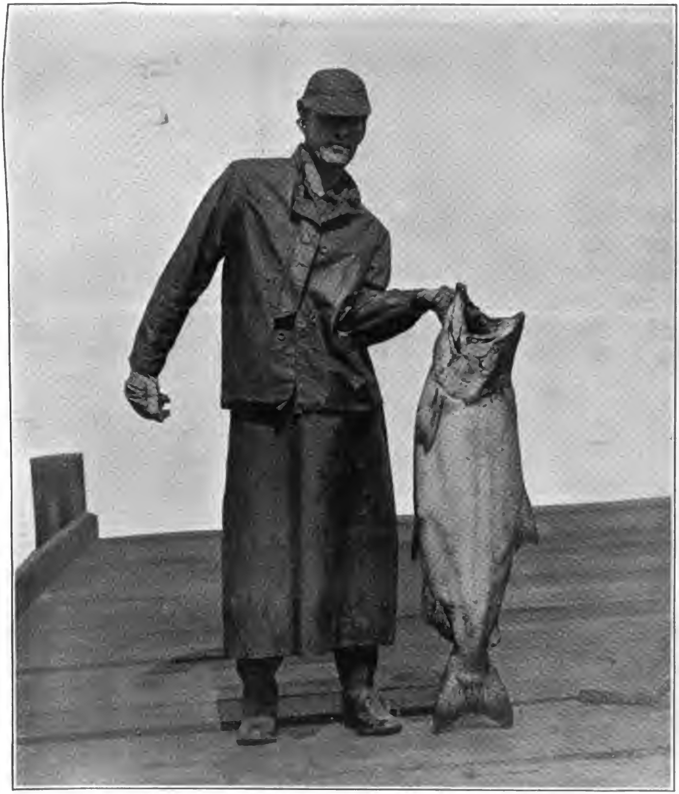

An 80-pound "Sockeye" salmon.

"CANNED GOLDFISH."—[See page 276.]

The Principles of Biochemistry*

Their Application in the Study of Colloidal Minerals and Their Resulting Use in Medicine

By John A. Handy, Ph.C., B.S., Phar.M.

Who knows what Life in all its phases really is? We note its characteristic manifestations in the mineral kingdom, in the animal kingdom, and in the human kingdom. We are even intuitively conscious of a still higher form of life. What are the various elements in nature which enter into our physical conception of Life? The intellectual giants of Science, Philosophy and Religion in all ages have grappled with the same problem, and yet, with all our heritage of knowledge and wisdom the problem awaits a complete solution.

The phenomena of spontaneous movement, irritability or response to stimuli, assimilation and dissassimilation (metabolism)[1], and even the processes of growth and reproduction, which are considered to be the peculiar characteristics of living matter, have all been singularly imitated by artificial means in the scientific laboratory.

However similar some of these artificial manifestations of living phenomena may be, they are not actual duplications of life or living material. There appears to be some element or principle present in the living protoplasm of nature which is not present in the artificial protoplasm of the laboratory. All of these experiments point to the fact that the chemistry and physics of the living organism are essentially the chemistry and physics of nitrogenous colloids—true organic or vitochemical compounds.

A vitochemical substance or preparation is one which consists of a colloidal mineral element or compound chemically associated with native organic substances—proteins, fats, carbohydrates, etc.—in that form of refinement of particle and degree of activity as most nearly approaches the form and combination of true organic vegetable or animal tissues. Prof. E. A. Schäfer, in his recent article on "The Nature, Origin, and Maintenance of Life," expresses the advanced views of contemporary Physical Science on the chemical constitution of living substance, when he says: "Living substance or protoplasm always, in fact, takes the form of a colloidal solution. The elements composing living substance are few in number. Those which are constantly present are carbon, hydrogen, oxygen, and nitrogen. With these both in nuclear matter and also, but to a less degree, in the more diffuse living material which we know as protoplasm, phosphorus is always associated. Moreover, a large proportion, rarely less than 70 per cent., of water appears essential for any manifestation of life, although not in all cases necessary for its continuance, since organisms are known which will bear the loss of the greater part if not the whole of the water they contain without permanent impairment of their vitality. The presence of certain inorganic salts is no less essential, chief among them being chloride of sodium and salts of calcium magnesium, potassium, and iron. *The combination of these elements into a colloidal compound represents the chemical basis of life,* and when the chemist succeeds in building up this compound, it will without doubt be found to exhibit the phenomena which we are in the habit of associating with the term of life."

A rational explanation and understanding of these biochemical elements and principles necessitates a brief consideration of Nature as a whole as a basis for the larger conception of a chemistry which deals with Life itself. Nature embraces certain fundamentals which are classified as ultimates, and which appear to be universal in time and space. These ultimates are five in number. Three of these—Matter (the universal property of Nature), Energy (the universal mode of Nature), and Life (the universal element of Nature)—command our especial attention at this time. A careful study of these universals reveals another stupendous fact, viz., that our whole system of evolutionary growth and development is brought about by the operation of a great fundamental law or principle of Nature acting through and upon these five ultimates.

This great fundamental principle is known to chemists as the Law of Chemical Affinity, and is refining in principle, evolutionary in growth, harmonic in operation, vibratory in activity, and constructive in effect. In short, it is Nature's universal formula for evolution, which refines matter, increases its vibratory activity, and generates life.

The biochemist, from a careful study of the broad field of Natural Science, takes the data of the chemist and physicist, of the anatomist and physiologist and pathologist, out of which he constructs an imagery of his own, dealing not with atoms and molecules as such, but with the conceptions of the physical and chemical nature of protoplasm, in the processes of reaction-velocity, catalysis and ferment activity, equilibrium, viscosity, osmotic pressure, colloidal mutability, allotropic transmutations, and electrolytic dissociation in vegetable and animal tissues. He must first, however, recognize and study the operations and manifestations of certain fundamental governing elements which coordinate the multiple phases of mineral and cellular activity, and appear to magnetize, vitalize, animate, and vivify respectively the four great kingdoms of nature, viz., the Mineral, the Vegetable, the Animal, and the Human kingdoms.

These governing elements, which are four in number and also appear to be universal in time and space, we may designate as the Life Elements. The science of chemistry is principally concerned with only two of these life elements, which are defined as follows: (1) Electromagnetism; (2) the vitochemical life element. It appears that one or more of the four life elements magnetizes, vivifies, vitalizes, or animates all physical matter, including the mineral atom, the plant, the animal, and the man. It would seem, then, that what we know as magnetism in minerals, vitality in vegetation, and physical life in the animal and man, are, in fact, certain temporary relations established between physical material and the finer and more subtle life elements.

The withdrawal of the life elements in each kingdom appears to produce the same result, viz., devitalization and death. Physical matter is, therefore, negative to and subject to the more positive life elements. The principle of affinity or polar attraction appears to inhere in the vital elements themselves, and not in the solid particles of physical matter. Each life element is also assumed to display dual and yet differing powers and capacities of positive and receptive energy.

In the mineral kingdom the constructive and integrating principle of Nature operates through the electromagnetic life element alone.

In the vegetable kingdom the constructive, integrating principle of Nature operates through two life elements instead of one. That is to say, it operates through the electromagnetic and the vitochemical life elements. Of these two life elements the vitochemical is the dominating one in vegetable organic process. It controls those higher functions of Nature associated with the properties of organization, growth and reproduction. The entire plant kingdom is an expression of the vitochemical element in Nature.

The operation of the law of polarity through the life elements upon the individual units, whether between the mineral atoms or the vegetable cells, is a ceaseless effort to establish vibratory correspondence and an equilibrium of forces in a perfect union. The result of these ceaseless activities of the individual particles upon each other is a refinement of the atom in the compound.

There comes a time when a portion of the mineral substance is raised to certain ratios of correspondence with the vibratory action of the next higher element of vitochemical life, which appears to lie universally and coextensively in time and space with the lower element of electromagnetism. When the mineral atom has been thus raised it becomes susceptible to the essence of coordination of the higher life element. Impregnation occurs. The vitochemical life element is inducted into mineral substance and the mineral atom becomes a vegetable particle endowed with vitochemical or vegetable life. Is it not reasonable to suppose that by this evolutionary process, guided by Nature's constructive principle, all life is generated upon this planet?

If all inorganic chemical compounds are the offspring of the electromagnetic element in Nature, is it not reasonable to suppose that these potential electromagnetic energies may be liberated from substances under certain conditions of chemical activity, and that electricity is one of the manifestations of this most simple of life elements?

Again, consider the properties and activities of vegetable protoplasm with its combined potentialities of electromagnetism and vitochemical energies. Take for example one of the simplest forms of vegetable life—the yeast cell. This cell, microscopic in size and possessing the simplest anatomical structure, and consisting simply of a colloidal solution of mineral salts in true organic or vitochemical form, is capable of growth and reproduction, and of carrying out many complex reactions. The yeast cell is capable of elaborating certain nitrogenous colloids called enzymes or ferments which convert sugar into alcohol, carbonic acid and water. Under certain conditions the yeast cell converts sugar into glycogen, which it may store for a long time within itself, or which it may soon reconvert into sugar and then into alcohol. Under other conditions it may oxidize alcohol. It synthesizes protein and cellulose. It forms glycerine, succinic acid, and amyl alcohol. It may reduce sulphur to sulphureted hydrogen. It generates electricity. It performs, undoubtedly, a whole series of cleavages, syntheses, oxidations, and reductions, and yet, examined under the microscope, it appears fairly homogeneous. No structure is visible capable of explanation as to how, in this small space, so many processes can go on side by side in an orderly fashion without interfering with each other. This multiple phase activity is manifestly impossible in a test tube.

Much experimental data and many interesting and clever theories have been advanced to demonstrate and explain the multiple activities of the simplest of living cells. These studies have all led to one fundamental principle, viz., that *co-ordination* is the great characteristic of life. Anything which intermixes protoplasm and thus disturbs its phases of activity destroys co-ordination, and protoplasm dies. In other words when the vitochemical life element escapes, co-ordination ceases, plasmolysis ensues, oxidation, hydrolyses, and the various other processes of the cell run riot, devitalization results, and we no longer have living material.

It is toward a clearer understanding and a scientific application of the vitochemical life element that the biochemist of today must direct all his efforts and apply all his knowledge of physical and chemical science if he would ever bridge over Nature's gulf between the mineral and the vegetable worlds and that between the vegetable and the animal worlds.

A simple experiment will demonstrate the action of the vitochemical life element by producing within a few minutes what looks like a profuse vegetable growth. The experiment is carried out by introducing into a colloidal solution of sodium silicate (sp. gr. 118) crystals (about the size of a pea) of salts of the heavy metals, such as ferric chloride, ferrous chloride, copper chloride, uranium nitrate, silver nitrate, gold chloride, cobalt nitrate, manganese sulphate, etc. One is then witnessing the actual transformation of the coarse crystalline inorganic form of matter to the more refined colloidal form. Similar results may be obtained by dropping into a fairly concentrated solution of potassium ferrocyanide little pills (size of a pea) made of copper sulphate or other heavy metal salts, and sugars.

A study of protoplasm leads one to conclude that the phenomena of "organic life" appear to be the manifestations of the universal vitochemical life element through colloidal matter.

Hermann Hille has recently claimed to have demonstrated the fact that colloidal minerals are Nature's bridge from the mineral kingdom to the vegetable kingdom. He is the first to make a successful application of the vitochemical principle in the study of colloids and the preparation of minerals and mineral salts in "true organic" form. He is the first to point out and demonstrate that true organic substances are colloidal forms of matter, and are, therefore, allotropic modifications of inorganic substances—the crystalline forms of matter.

All physical nature is divided into the inorganic world of mineral matter and the organic world of vegetable and animal matter. Chemical analysis reveals the fact that the inorganic world is composed of the same elements that are found in the organic world. From the viewpoint of chemistry of today, therefore, the difference between organic and inorganic is not chemical in character, but a difference in structure only. The characteristic structure of the inorganic world is rigid and crystalline; its basis is the crystal. The characteristic structure of the organic world is plastic or colloidal; its basis is the cell. Thomas Graham classified inorganic matter as "crystalloid" and organic matter as "colloid." Organic substance (the colloidal form of matter), therefore, is an allotropic[2] modification of inorganic substance, the crystalline form of matter.

For example: Diamond and charcoal and the carbon of protoplasm, in a purely chemical sense, are the same, so far as we know. They are allotropic forms of the element carbon. The diamond is crystalline or inorganic;

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*Extracts from a paper read before the Section on Pharmacology and Therapeutics of the American Medical Association. Reprinted from the *Medical Record*.

[1] The terms "assimilation" and "dissassimilation" express the physical and chemical changes which occur within protoplasm as the result of the intake of nutrient material from the circumambient medium and its ultimate transformation into waste products which are passed out again into that medium; the whole cycle of these changes being embraced under the term "metabolism."

[2] By allotropy is understood the property which certain chemical elements have of existing in two or more distinct forms, each having certain characteristics peculiar to itself.

charcoal is an amorphous or semiorganic form of carbon, whereas the carbon in protoplasm is the true organic or cellular modification.

The results already obtained in colloidal chemistry make it safe to proclaim that every known substance can be raised from the crystalline to the more refined colloidal form.

Experiments with colloidal metals by Fillipi, Henri, Stodel, Ascoli, Izar, and others demonstrate that colloidal metals are as powerful in their bactericidal action as their inorganic salts, but very much less poisonous, if at all, in their effects upon ferments like pepsin, trypsin, pancreatin, etc. The effect of colloidal metals upon the enzymes of autolysis, or autodigestion has been found to be accelerating and beneficent. In fact, colloidal metals in themselves possess ferment action which can be retarded or entirely annihilated by traces of poisons like hydrocyanic acid, bichloride and cyanide of mercury, arsenous acid, carbon monoxide, etc. In other words, colloidal metals can be poisoned like other organized substances.

Not only the metals and other elements can be produced in the colloidal form, but their salts and other combinations as well. It is invariably found that the colloidal form is very much less poisonous and injurious than the crystalline form. For example: Colloidal copper arsenate is said to be one million times less poisonous than crystalline copper arsenate.

All of our wholesome, natural food is colloidal in its nature. Milk, butter, cheese, eggs, meat, vegetables, fruits, honey, etc., are all colloids—not only their protein, carbohydrate, and fat constituents, but also their mineral bodies in true organic or vitochemical form, which have been almost totally ignored in medicine and dietetics, appear to be of such vital importance that "not one of the vital processes of the human organism is possible without them." Progressive physicians are beginning to recognize that the mineral salts of our food, which were formerly considered more or less unimportant, or secondary in importance to the three main classes—proteins, carbohydrates, and fats—are of the first importance.

The natural mineral salts are not only of the first importance as tissue foods, but are also the chief waste eliminators in human metabolism. To get some idea of the promptness with which the body acts in the elimination of waste matter and to emphasize the importance of taking our mineral salts in true organic form, wherein they will act as foods rather than as irritants to protoplasm, try the following experiment: Eat a tablet of lithium citrate. Then take a clean platinum wire, hold it in a colorless flame of a bunsen burner and note that it gives no coloration to the flame. Now pass the wire along the skin of the forehead, or after rinsing the hand in distilled water draw the wire across the palm and again hold it to the colorless bunsen flame. Note the beautiful yellow color due to the presence of the sodium. Next take the blue glass and observe the yellow flame through this; the cobalt glass absorbs the yellow sodium rays and the lilac flame of potassium now shows. About a half hour after taking the lithia tablet make the same test as above with a clean platinum wire. The vivid red flame of lithium is now obtained. In one short half hour the lithium entering at the mouth has been absorbed into the blood and carried to all parts of the body and is being excreted through the skin.

Is it not true that if the physician can control nutrition he can control disease? If it is true, and I believe it is, then a thorough knowledge of the mineral salts in true organic or vitochemical form—both in their native occurence in our natural foods and in their synthetic forms—is necessary

An interesting conclusion in connection with the relative value and importance of vegetable and animal foods in the human economy may be drawn from the following facts: As a general rule the chemical changes in plants are progressive or constructive; in an animal, regressive or destructive. Some cleavages are brought about in plants and some syntheses are carried on in animals. Animals take up the organic vegetable substances which have been synthesized by plants, assimilate them and excrete waste products which are identical or nearly so, with those substances serving as food for plants. Animal food will, therefore, contain its own waste which will be so much extra inert and poisonous material for the human organism to eliminate. In the case of plant foods we do not have this extra waste material to take care of.

The facts of modern science, with their references, bearing upon the important subject of mineral starvation and disease, have been comprehensively reviewed in a recent article by Hermann Hille in the *Medical Record* of June 15, 1912. Dr. Hille draws the following significant conclusions: First, that the primary cause of disease, from a purely physical viewpoint, is chiefly mineral starvation, and, second, that minerals in inorganic form cannot be utilized by the human organism as directly and effectually as can true organic minerals.

Dr. H. Packard, in a recent article on "The possible Factor in the Causation of Cancer," in the February issue of *Surgery, Gynecology and Obstetrics*, writes as follows: "In view of the apparently well established fact that in the vegetable world an adequate supply of the earth salts—phosphorus, potassium, iron, manganese, silica, sodium, etc.—act as a distinct deterrent on parasitic life, and make for vigorous, virile, disease-resisting, healthy life, may we not assume as much for the animal world?

The possibilities of the application of colloidal chemistry in medicine are suggested, not only by some of the colloidal preparations mentioned here, but also by the results obtained by *Prof.* Martin H. Fisher, whose recent publications, "The Oedema" and "Nephritis" and their subsequent discussions by William J. Gies and others are of value and interest to every thinking and progressive physician.

A clearer understanding of colloids and a more intimate knowledge of the facts of colloidal chemistry and of the vital importance of the colloidal forms of matter for the manifestations of organic life and in the elimination of pathological conditions will not only accomplish a much needed simplification of materia medica, but will also facilitate a rational understanding of the primary causes of disease and will thereby elevate the uncertain art of healing to the dignity of an exact science. It would enable the physician to know why a remedy ought to be colloidal or organic, and why crystalline or inorganic remedies are foreign matter to the human organism and act as poisons and irritants instead of foods.

A careful study of the vitochemical principle in Nature, and its application in biochemical research, will revolutionize our chemistry of today and give us a new materia medica for the future.

The Sense of Taste

By Alfred J. Lotka

The sense of taste and smell are in a class by themselves and differ in certain respects from the other special senses. They have been described as the chemical senses; and since chemical action can take place only between substances in actual contact, we can become aware of the smell or taste of a given material only by actual contact with it or its vapors. This places a certain restriction upon the scope of these senses, as compared for example with sight and hearing. In man, at any rate, the chemical senses are not developed to the same degree of refinement as sight and hearing. Nevertheless they fulfill very important functions, their primary purpose being, no doubt, to enable the individual to exercise the proper judgment in the selection of his food. This is indicated by the location of the organs of smell and taste in and near the mouth. In the case of animals the senses of taste and smell do very efficiently fulfill this function; in fact, the presumption is that animals have no other means of distinguishing healthy from injurious or poisonous materials for food. In the case of man, the same reliance cannot be placed upon the sense of taste, as some poisons have a pleasant taste, and some substances which are more or less harmless have a disagreeable taste. Aside from the perfectly normal discrepancies between our likes and dislikes in the matter of taste, and the things that are good for us or otherwise, individual persons may be subject to various peculiar abnormal vagaries of the sense of taste. The simplest of these is a more or less complete "taste blindness," which accompanies various diseased conditions ranging in seriousness from a common cold to incurable affections of the central nervous system. In the case of general paralysis it is especially the sense for saltiness that is lost. People subject to epileptic fits almost invariably lose the sense for sweetness, often also for saltiness, but usually not that for bitterness, at the time of one of their attacks. Sometimes it is only one-half—usually the left—of the mouth and tongue that loses its sensitiveness. Persecution maniacs who are in fear of being poisoned often have an exaggerated sense of taste.

Occasionally a peculiar case is found in which different tastes are confused; the patient for example, asserts that a bitter substance tastes salty to him. In the case of neuropathic persons, that is to say, persons of somewhat unstable mental balance, certain tastes are sometimes associated with color sensations. A temporary loss of the sense of taste can be produced at will by painting the tongue with certain drugs. Cocaine, if applied somewhat liberally, causes local anesthesia: in mild applications it merely deadens the sense for bitterness. Some insane persons are subject to "taste hallucinations." Perversions of the taste, more or less morbid in character, are observed in hysterical and other persons. There is a certain disease in which the patient will eat all sorts of unsavory and even disgusting things. Without going to such lengths as this, many people have a preference for meat, especially venison, which has been allowed to undergo partial putrefaction. Some savages do not draw the line at a *partial* putrefaction, and show undisguised signs of great gusto in devouring materials which would turn the civilized man sick.

A peculiar and interesting phenomenon is that of *inversion or contrast effects* of the sense of taste. After partaking of something very salty or very bitter, pure water tastes sweet. This perhaps is not very surprising, but a one per cent solution of potassium chlorate, which has itself very little taste, causes water taken into the mouth after such solution to taste intensely sweet. If the mouth is rinsed with copper sulfate or potassium permanganate solution, cigar smoke acquires a repulsively sweet taste. A somewhat similar observation is recorded by Gattermann, who states that if the air contains mere traces of prussic acid, cigar smoke acquires a peculiar taste, which thus furnishes an efficient alarm signal.

Substances possessing a marked flavor are of great importance in daily life, perhaps none more so than salt, sugar, and vinegar. As regards the first of these, it is absolutely indispensable and there is no substitute for it. The place of vinegar can in a measure be taken by other acids, such as for instance, lemon juice. Sugar is not one single substance, but is the name given to an entire class of more or less closely related compounds containing carbon, hydrogen and oxygen. Sugar fulfills a double function, being both a food in itself, and, on account of its pleasant taste, an appetizer.

In the diseased condition known as diabetes, sugar becomes highly injurious to the patient, who is thus condemned to a rather monotonous diet. Fortunately modern chemistry knows several substitutes for sugar, notably saccharin, which not only equals but vastly surpasses sugar for sweetening power, while being at the same time quite non-poisonous, to judge by experiments upon man and animals. Thus, for example, one person in nine days consumed 520 grams of the sodium salt of saccharin, a quantity which ordinarily would be sufficient for four or five years' needs, and showed no ill effects whatever. It is sometimes stated that animals will not eat foods sweetened with saccharin. This does not seem to be true, except perhaps for ants and bees, who require sugar, not on account of its sweetness, but on account of its food qualities. Saccharin has no value as a food, and moreover, it is so intensely sweet that the quantities ordinarily taken with the food would be negligible even if it had a food value.

The chemistry of flavoring material, and the study of chemical constitution in relation to the taste of various substances has grown to large dimensions, yet until recently no one collected work of reference on the subject was available. This gap has just been filled by a book from the pen of Dr. G. Cohn, on Organic Flavoring Materials, published in Berlin by F. Siemenroth, from the introduction of which many of the data given above are taken. The bulk of the book is highly technical and gives a mass of data regarding the taste of a large number of organic substances. For those working in this field, whether from purely scientific interest or for the sake of applications to practical ends, this collection should prove very valuable.

We have here culled out points of interest to the general reader, and will close with one more observation of this character taken from the chapter of Psychology of Taste. It is rather surprising to read that girls have a more sensitive taste for bitter and boys for sweet. Their taste for saltiness is equally sensitive. Adult woman has a more highly developed sense of taste than man for sweet, bitter and sour. For salty materials there is not much difference, if anything man is a little more sensitive than woman. A facetious person might be tempted to say that this must be taken with a grain of salt.

A New Method of Tapping Blast Furnaces

The old method of tapping blast furnaces was by means of a long, pointed steel bar, and not only was the operation dangerous, but it was also a slow one, and it was superseded not long ago by a hand drill. Recently an electric drill has been introduced which is supported by a long handle, and is capable of making a 2½-inch hole. The operating switch is placed in the end of the handle and is so designed that the power is automatically cut off as soon as the operator lets go the handle. It is said that a furnace can be tapped with this machine in less than five minutes, the actual drilling time not exceeding two minutes. The electric drill is withdrawn when within an inch or so of the iron, the final tap being made, as usual, with a long bar of steel. Drills of this type are being used by the Carnegie Steel Company, Pittsburgh, at its various blast furnaces. The drill shanks are about ten feet in length, about three feet of which is twisted. The drill is 2½ inches in diameter. At the Edgar Thomson plant at Pittsburgh the drill is hung on a special crane, which is so arranged that danger of accident to the operator is obviated.

"Canned Goldfish"

The Rich Harvest of the North Pacific Coast

By M. J. Herbert

Soldiers during the Spanish-American war ate so much canned salmon that they grew tired of it, and in a spirit of derision named it "canned goldfish," from the color of the meat. To the northwest section of this country and Alaska it is indeed "canned goldfish." And a fish cannery is far better than a gold mine.

Three million and a half cases of salmon, valued at more than sixteen millions of dollars, were taken from a strip of water reaching from the salmon banks of Puget Sound to the mouth of the Fraser River, a total length of forty-five miles, from July 15th to September 15th, last year. Think of it, eight millions a month garnered from "Father Neptune" without as much as by your leave! If this were a placer strike in Alaska newspapers from coast to coast would have scare headlines a yard long, and the news would relegate war scares to the second page. As it was, the fact was hardly commented upon, even by the local papers.

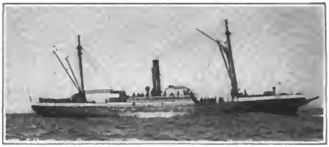
The value of the salmon canned on the Pacific coast is exceeded by one industry only—the lumber business. Yet far more money is spent in the process of production in the salmon canning industry than in the lumber. The opinion prevails in some quarters that this industry is one which thrives on the destruction of the raw product which it uses and requires but little outside the raw product for its maintenance.

Thirty million dollars is spent annually in putting up salmon pack, labor taking the lion's share, amounting to six and a half million, the fish about six million, the balance of this princely sum being eaten up by miscellaneous materials. The value of last year's pack was over thirty-seven million dollars, and this does not include the fish sold fresh at local markets.

The salmon are caught by seines, traps, or fishwheels in the rivers or sounds, on the way to the spawning grounds after they leave the sea. As soon as caught they are hurried to the canneries as rapidly as possible, where they are unloaded on the docks by means of elevators. The dressing or "butchering," as it is called, is done speedily, mostly by machinery. The head and tails are sawed off on a band saw, where formerly they were cut off by a cleaver, in the hands of a Chinaman. The fish is then fed, tail first, into the "chink," which is the cleaning machine that displaced the Chinaman as a cannery laborer a number of years ago. By one revolution of the wheel the fins are removed, the body split open, the viscera torn out, the interior wall scrubbed by revolving brushes, and the dressed fish delivered into a tank of water. It is then placed upon a specially slitted elevator which feeds it into a series of revolving knives, or disks, which cut it into lengths

Cutting machine and mechanical "chink."

Drying room, containing 4,000,000 cans.



U. S. Revenue cutter Grant, sold and converted into a fishing steamer. Wrecked on Alaska coast, 1912.

Unloading fish to an elevator at the packing house.

Labeling and boxing the cans.

Gathering the salmon catch in a fish trap.

It is estimated that the catch of such a trap is 2,300 salmon every twenty-four hours, averaging eight pounds. During the height of the salmon season these fish sell for five cents a pound at the trap.

corresponding to the height of the can it is intended for. There are a variety of lengths used, only three of which are standard, commercially known as No. 1 tall, No. 1 flat, and the half pound cans.

The grading of the fish is done on the basis of solid and less desirable cuts. Cans are generally filled by machinery, but a few choice parts are packed by hand. The cans are boiled in retorts at a temperature of about 250 deg. Fahr. for two hours, then taken out, dipped in lye to take the grease off the cans, dried, labeled and packed, forty-eight tins to a box.

The salmon canner is a real Santa Claus in a way, his operations eventually playing an important part in gladdening the hearts of hundreds of thousands of small boys the world over, for the ranks of the armies of brave tin soldiers which march annually from the toy factories of Germany, to capture the heart of the war-loving boy, are replenished each year by the salmon cans of the Pacific coast. The scraps and odd pieces of tin are carefully saved, baled, and exported to Germany, where they enter into the composition of the doughty red and blue warriors who wage war so relentlessly upon one another, on the world's nursery floors. But real war has now suspended this industry.

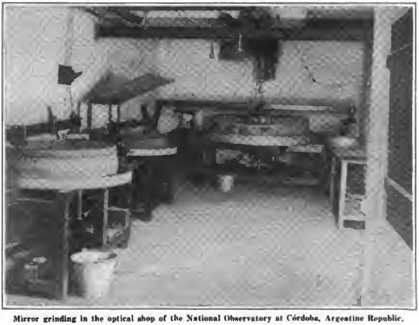
Optical Shop of the National Observatory of the Argentine Republic

By J. O. Mulvey

THE optical shop was established in 1913, chiefly for the construction of the mirrors required for the reflecting telescope of 1½ meters aperture provided by the government for the Córdoba Observatory. In addition to this, we are also making the mirrors for a reflecting telescope of 30 inches aperture and a 36-inch test plane for testing the parabolic mirrors. In order to have as little interference as possible a machine was made for each of these, and the illustration shows the three machines in the position they occupy.

The optical shop is in the basement of one of the observatory buildings where temperature conditions are very even and changes take place slowly, the observed difference of temperature between extreme winter and summer being only 11 deg. Cent., and between day and night is inappreciable. A tunnel extending from one end of the shop gives a length of 65 feet for testing.

Each of the machines is provided with an overhead trolley and hoist for handling the glass disks and heavy cast iron grinding tools. No difficulty was experienced in making cast iron grinding tools for the 61-inch mirror of sufficient stiffness and still light enough not to require counterbalancing. The three machines are the same in principle, the only difference being in some of the details on account of the difference in size of the work they are to do. Independent motor drive is used. The problem of reducing the speed of the motor from 1,800 revolutions to 25 and 27 revolutions per minute (the speeds of the driving arm and turntable shafts in the large machine) is met through spiral or worm gearing. Gearing of this class is often looked upon with suspicion by mechanics, but if properly made and applied is very efficient, a one horse-power motor supplying ample power for our large machine. All upright spindles have ball end thrusts. These machines are very steady and smooth in operation and are under perfect control of the op-



Mirror grinding in the optical shop of the National Observatory at Córdoba, Argentine Republic.

erator. They are compact and take up very little room considering the size work they are doing.

The preliminary testing of the 30-inch flat is being done without removing the work from the machine. At the end of the day's work the polishing tool is removed and the disk cleaned, and a 12-inch test plane placed upon it and left over night for the temperature to even up. In the morning the work is examined by a mercury arc light, the interference bands showing the high or low places, after which the tool is trimmed accordingly and work resumed. The final testing will have to be done by setting up in connection with a perfected spherical surface, and tested at the center of curvature by an artificial star. The 61-inch disk will have to be perfected for this and afterwards parabolized. The artificial star apparatus has a portable arc lamp for an illuminator. This gives a very brilliant star and permits the use of a very small aperture, enabling the operator to see very small irregularities of figure. The perfecting of figure on mirrors of this class has to be carried to a very fine degree of accuracy, the demand being constantly for something better, and the optician's skill is taxed to its limit. The ability of an optician lies largely in his skill of testing.

At the end of the tunnel, away from the grinding machines, is the dividing engine for ruling diffraction gratings. This machine has been perfected to the point where it shows no appreciable errors by the crossed line ruling test as used by Rowland. On account of the great amount of other work on hand, but little regular time has been given to this machine, most of the work being done on the holidays, of which there are many here. It is hoped to get gratings of about 120,000 lines resolving power from this machine, providing very valuable instruments.

Thorough ventilation is given the optical shop by forcing air slowly through a large underground passage 70 feet long. This gives the dust a chance to settle and fresh air enters at room temperature.

The writer divides his time between the optical shop and construction work, and as there is no assistant on the optical work, progress is more slow than would otherwise be the case. The smaller disks have advanced to the point of testing, but the large disk is still in the roughing stage. The large disk will clear up 61 inches in diameter, is 10 inches thick, and weighs 1 ton. The 30-inch telescope will be used at the Córdoba Observatory, but the large telescope will be placed in the mountains a few miles west of Córdoba.

The Value of Radium in Surgery

An Estimate Based on Our Present Knowledge

By Robert Abbe, M.D., Senior Surgeon to St. Luke's Hospital, New York

Truth is revealed slowly in science—as words spell themselves out letter by letter. The whole truth about radium will be written years hence, for we are in the first decade and its importance still grows. Ten years ago Prof. Rutherford, who is easily the first authority to-day on the subject, said to me that the physicist then knew about all that was likely to be known about radium, and it was the work of the medical profession to see what it would do in their hands. Since then he has issued a new edition of his great work every year or so, old ideas being obsolete, and still finds that it is the newest wonder in science. Is it any marvel that its usefulness cannot be estimated by our present knowledge of its ability to cure? The only regret is that the profession and public have been expecting too much. People who expect too much are never happy when they get less than they expect.

We are dealing with a wonder-working mineral unlike any other agent in our hands. While it resembles the energy of the Roentgen ray, it is unlike it in many ways. The output of a small bit of radium powder is a composite force largely electrical, but unlike electricity in any form heretofore known to professional work. It is associated with the extraordinary discharge of infinitely numerous streams of particles each bearing its charge of electricity, some positive, some negative, resulting from the explosions of atoms with a force driving them into tissues with the speed of light. Into nature's rocks, by the most artful exhibition of scientific detective work, Madame Curie pursued this unknown substance and dragged it forth, a little giant in power, to reveal the hidden mysteries of physical force and touch human interests in the control of some diseases. In itself radium illustrates in concentrated form the universal process of change and decay of matter. Its enormous energy is like incorporated life, and its electrons like imprisoned life released.

The first surprise we all felt at seeing a photograph by the Roentgen ray through an opaque body is eclipsed by the photograph made with the same marvelous penetrating power of a tiny pinch of radium confined in a glass tube, photographing through the human body, or a granite boulder, or some several inches of steel. As it penetrates stone or steel, it moves in undeviating lines. Nothing can deflect its direct movement, or resist the destructive power of its impact. Yet it carries into the tissues also a material force not *destructive*, but a subtle power to help—a *constructive* force—which the keenest study has not yet analyzed or harnessed. This is a *stimulating* force recognized first in its effect on plant life, and later brought into use to explain some of the phenomena of its influence on tumors.

At this point all argument has to give way to observation. Until we know why cells grow, what innate power resides in living tissue which compels growth and orderly change in living cells, and until we know why the disorderly and exaggerated overgrowth of cells forms life-destroying tumors, we will not be likely to know what the influence is which is shot into the cells by the atoms of radium which reduces them to orderly growth. One observer may theorize about the known bactericidal power of some rays from radium being responsible for the alteration of tumors; another, that the chemical changes brought about in the delicate protoplasm may alter their growth; another may advance an hypothesis that the even course of cell growth may be due to a balance between a positive and a negative electric charge in each cell which controls its acts, for they seem to respond to electrical affinities, and that the loss of one might permit an unbalanced and inordinate overgrowth, which a due supply of beta rays of radium each carrying a negative charge of electricity might correct. In any case the sophism of Huxley that "theories help us to bear our ignorance of facts" reminds us that one must revert to the habit of observation for the most part if one would make well grounded advances. So let us now drop all blinding sense of wonderment or misleading or distracting theories and argue on facts alone.

Many have lost sight of the first uncontroverted claims of the action of radium in retarding seed growth, or in repressing animal life, as shown by the prolongation of the worm stage of radiumized worms while the unradiumized brother and sister worms passed into the chrysalis and succeeding beetle stage, completing the cycle by laying eggs which become worms again, while the radiumized worm remain unchanged—a sort of Methuselah; or, again, the irritative spinal meningitis in mice exposed to radium; or, the disappearance of superficial epitheliomas of the face under radium. Were that all that could be claimed it would be a small contribution indeed. Each year, however, has added something to the credit of its utility. Of this it may well be said that, considering the small amount in existence and the few observers, it is amazing that so much can already be claimed. It is as if a hundred scalpels only were in existence in the world instead of a million for ingenious and experienced men to use.

It is not yet known how best to use radium, whether in strong form or dilute, whether in naked form on a varnished surface or confined behind thin or thick metal filters, to hold back some classes of rays, or in the form of emanations. In view then of the confusion of method and the long time needed to attain permanent results by the few cautious observers, it is no wonder that slow progress is being made. Its evolution is not unlike that of the flying machine, only just now beginning to be practically useful.

Perhaps the first unqualified proof of its conquest of disease was in its dissipating the epithelial cancers of the face. Grant that it followed the same efficient action of Roentgen rays demonstrated to the credit of that marvel; grant that surgery had for generations been able to treat successfully these same small growths by cutting them out or burning them out by cautery or chemicals! By these means we have formerly cured the patient—and we still do so—but we never cured the disease—we only removed it. Now comes a new and subtle power which cures the disease, drives back into orderly life the disorderly cells constituting a tumor. We hold our breath in surprise—and rightly so!

A natural question now arises. Is there here a specific action? Is there a selective action against the component cells of a tumor discriminating in favor of those of healthy growth? We answer, yes, and offer proof by several facts. First, consider myeloid sarcomas. A myeloid sarcoma is an overgrowth of the myeloblasts of the bone marrow. As they increase enormously they destroy the calcific bone by pressure or absorption, until all semblance of the bone is gone and is replaced by a pultaceous mass of soft tumor. In the near future the life of the patient may be sacrificed. During the growth of the tumor a correct dose of radium is given, and the cells not only cease growing but retrograde, and permit a reformation of the bone with its original structure and form. We have to assume that the enormous production of marrow cells has been reduced by atrophy and absorption during the cure, or that out of the riotous overgrowth of new weak cells the primitive cells have reassembled and returned to their normal life work. That certainly seems like a selective action against weak cells. Why has the vicious growing tumor halted and begun to retrograde immediately upon the application of a shower of radium rays? All that has been done has been to use beta rays, of which we know little except that each atom carries a charge of negative electricity, and gamma rays with no electrical charge, but a wave stimulation exceeding the speed of light. The effect is not transient but lasting.

The first startling case I had was of a patient part of whose lower jaw was destroyed by a pure myeloid tumor in which the teeth were set as if in jelly. Radium rapidly reduced the mass until gritty bone began to form and the entire jaw was re-established in shape and structure, with teeth solidly embedded, and this has remained as perfect as a normal jaw for ten years. This type of destructive tumor seems to be uniformly and quickly cured by radium. Ten cases have demonstrated this in my hands, some in the upper or lower jaw, others in the long bones. This I would call a specific act of a certain influence discriminating against disordered cell growth, and sparing healthy cells scattered throughout the tumor tissue.

Scores of similar effects could be quoted, but I will speak of only three others. The first was of a man on whose lower eyelid grew a tumor which in a year occupied more than half its breadth, pushed the lid from the eyeball and grew upward from the lid and downward on the cheek, a large purple tumor pronounced sarcoma by microscopic study. It was given expert Roentgen ray treatment twenty times with no benefit. After four hours of radium from a small tube laid upon it, it melted away day by day and was gone in eight weeks. From year to year for eight years I asked many medical men to say on which lid the growth had been. The eyelid had been entirely engulfed by the disease, but out of the mass there were reassembled the original cells of the skin, of the sharp edges of the lid, of the hair bulbs and follicles, so that hairs grew again on the restored lid. Repeated examination of the microscopic slides has led to dispute as to whether to class it epithelioma or sarcoma. Clinically it did not resemble epithelioma. In either case the radium acted as a specific cure.

Again, I ask you to consider a case of the type of round-celled sarcoma of the parietal bone of the skull. During one year the bone had been eaten away and replaced by a tumor of the area of one's palm, resting on the dura and lifting the scalp two inches from it. A section removed for examination showed a round-celled sarcoma. A silver tube with one hundred milligrammes of radium was inserted through it in two places and left eight hours in each. The tumor melted away until in three months it was gone, all but the thickness of blotting which shows a remnant of the same cells, entirely inert, in the fibrous stroma.

Finally, as showing a definite specific and selective action, one sees a papilloma in any part of the body disappear uniformly after thirty minutes of radium influence. This I have verified more than a hundred times. But the special point I would emphasize is the fact that where, as in the larynx, the vocal cords are buried in masses of papilloma filling the laryngeal space, the tumors disappear and leave normal glistening white vocal cords—the speaking and even fine singing power return. This proves, even more than gross appearance, that the delicate original tissue on which the tumor was built up, and from which it sprang, is not affected by the radium rays which caused the tumor to disappear. A dozen such cases in my hands have shown its infallible action.

One may also assert its specific action in all basal-celled epitheliomas. One may perhaps choose to call it a repressive action which causes every such tumor to retrograde immediately and permanently, in so far as a ten-year "cure" may be called permanent.

There is now accumulating also a series of cases of myoma, uterine fibroids, in which one or two irradiations of the tumor from the uterine cavity have been followed by progressive shrinkage year after year, until the growth was almost wholly gone, as if the disturbed cell reproduction had been corrected, quite like the types just mentioned.

It becomes us now to speak of some contrasting failures in a different type, the sarcoma which are composed of spindle cells sometimes mixed with a few large free cells, springing from and destroying bone very much like the myeloids, but not composed of or containing true myeloplaques. I have vainly endeavored to bring about a retrograde change in these tumors for many years, but have made no favorable impression on them, thus far, by radium. Beginning with a spindle-celled tumor of the temporal bone ten years ago, I have failed in this type, in several fair attempts in similar ones of the tibia, femur, and radius, and of some in the soft tissues, as in the popliteal space. I cannot even claim to have retarded or altered their growth; nor has the microscopic or gross appearance of the radiumized areas shown the specific affects of radium work. This is true also of some types of epithelioma of the skin, the squamous-celled type. Indeed, I have come to regard a resisting epithelial cancer as probably of that type before microscopic corroboration is given. The squamous-celled type are prone to invade the nearest lymphatic gland which the basal-celled tumor does not. By this the surgeon will be warned to resort quickly to thorough use of his keenest dissecting skill. Fortunately this type is relatively infrequent. It is evident then that discrimination in using radium is essential, most of all in the choice of cases, if we would bring this efficient agent into repute for its true value.

Yet there is a greater field of work, that of cancer, which must now be approached with all the skill and judgment of ripe experience, which has baffled surgeons of all times, and which is only now being touched by the new agents. With the preliminary facts which I have gone over, we are prepared to take the next step forward. First, I ask, has science revealed the nature of cancer in the virulent form which the public and all practitioners know it? It has not. We only know its gross and its microscopic appearance, its course, and its statistics. It has always been classed among malignant diseases, malignant in the sense that it is a life-destroying growth, composed of cells which in the beginning are a part of the normal cells of our body. In the judgment of pathologists a cancer of the uterine cervix begins as an epithelioma of the cervical mucous membrane; that of the stomach as an epithelioma of the follicles of the lining membrane; that of the breast as an epithelioma of the duct follicles; cancer of the rectum originates in the epithelial mucous gland structures.

If we could radiate the disease in its early groups, we could end it. Such facts exist. I have one patient whose cervix curettings showed early invasion of the submucous structure by proliferating epithelium, a typical early cancer in which radium treatment alone has given a cure of nine years. In only one other form of beginning cancer, that of the breast, where it begins as an epithelioma of the nipple, for which surgeons would always advise mammary amputation, have we an opportunity to test the value of radium in the early stage. In six such cases I have caused prompt disappearance of the growth and maintained subsequent health for several years.

During the years of trial I have necessarily tested radium in many of the massive and inoperable types of cancer, hard scirrhus breasts, encephaloid tumors, large fungating rectal cancers, and tongue cancers of all stages. It was right and just to the subject that these should be carefully subjected to test. I may also say that many terrible cases, from a surgical point of view wholly inoperable, have been offered to me by my surgical friends as a challenge which I have rarely refused. So that out of the mass of the history of ten years I can speak in general terms with some precision.

It is no small tribute to radium to say that in one-tenth of these active cancers a retardation can be seen and one third in time added to the expectation of life. The method of action of radium in cancer does not seem to me to be specific in the sense that it is in the diseases narrated earlier. Ten years ago I satisfied myself that radium kills the cancer cells in the groups nearby it, but within a limited radius, perhaps a quarter of an inch, and that to destroy large masses many tubes must be placed throughout the tumor. In such cases there was always tissue necrosis with more or less toxemia which always passed away safely. In the earliest days of its extreme use I occasionally observed a temperature of 103 degrees to 105 degrees, never serious for more than one to two days. This was followed by excellent repair. Perhaps I have never sufficiently followed up such cases by further attacks on the neighboring tissues, because they have been associated with pre-existing lymphatic disease, which made the task too hopeless. This method of attack is quite like that of Krönig, Bumm, Voight, and others who have given massive doses in uterine cancer to radiumize the gross mass and have felt that far better results were attained than by excision. Experimental work in this field is still being conducted, not without hope.

One practical, and demonstrated gain to surgery is seen in the principle enunciated by Wickham that if all the massive cancer cannot be removed, radium can be successfully applied to the thin shell of disease necessarily left, with the certainty that it will be destroyed. In one patient I was obliged to leave a thin layer of cancer grown to the wall of the carotid artery at its origin which, however, I radiumized *in situ*. Five years of perfect health have gone by with no recurrence. This principle of killing and safely leaving a small remnant of malignant tumor is of the greatest importance to surgery. It applies to every part of the body. Hence the postoperative use of radium promises to be a material advance.

But the most definitely good effect of radium work in these several cancers seems to follow the blocking of all the vessels nourishing the growth by a process of endarteritis. This irritation is of inestimable value in all radium work where high vascularity and active cell growth are present. Nothing so efficient in treating nevi, either capillary or angiomatous, is known to surgery. It effects a delicate blockading of vessels by endarteritis. Nor is this second to the beautiful results of radium in keloids. The true or the false keloid which no surgeon dares to touch with a knife, yields uniformly to the irradiation by radium which induces a soft fibrosis in the regular and active cellular structure, from which the accompanying itching and burning speedily vanish.

Not the least important rôle played by radium is in its special influence in causing retrograde metamorphoses in hypertrophic glandular structures like thyroids, lymph adenomas, lymphosarcomas, parotids, etc. This widens the important field of usefulness. I have treated half a hundred goiters of all varieties by radium alone, and have seen complete disappearance in a few and checked the growth in many. The ideal treatment for most troublesome cases is thyroidectomy. Nevertheless there is a large proportion of goiter patients either not greatly annoyed, or unfit for surgery, where radium is applicable.

Every physician feels the sense of helplessness when confronted by advanced cancer of the tongue. Even with thorough surgical extirpation early return of the disease is well-nigh certain. I have been impressed by the temporary improvement in many bad cases after using radium alone and have now adopted the combined extirpation followed by radium with a degree of hope, because of some cases of long freedom where the half tongue was first removed. Several years will be necessary to speak of cures.

It is difficult to know where to draw the pathological lines on tumors affected favorably by radium. It would almost seem as if all aberrant cell growths ought to be controlled, if some are, but certainly at present it seems that the myeloid and round-celled sarcomas and all tumors of lymphoid type yield wholly or in part and that basalcelled, but not squamous-celled growths are consistently curable. Tonsil sarcomas, some gliomas, pharyngeal neoplasms all yield some cases to the credit of radium. It is far too early to classify the types.

It is fair to say in conclusion that, stripped of all extravagant claims, radium is an asset of permanent value to surgery in the treatment of those diseases, some of them justly called malignant, which I have heretofore defined. In the graver form of cancer, which has so long baffled us all, some definite progress has been made as described, but hard research work must yet be done before someone puts his finger on the weak spot in its method of use.

Finally, let me add that one must pardon the occasional outburst of enthusiasm from those who are beginning the use of radium and are startled by its revelations. These are more than offset by the occasional tirades against it either by those who have never used it, or by those who have some other method to exploit. Both these are natural as they are negligible. They do not affect the real truth that as an agent for the relief of human suffering radium has proved to be a weapon of unique value in the surgeon's hands.

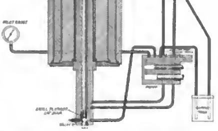
The Accurate Measurement of Hydraulic Pressures

The National Bureau of Standards at Washington, D. C., has recently installed an instrument for accurately measuring hydraulic pressures up to 4,000 pounds per square inch. This instrument is shown diagrammatically in the line drawing to illustrate the principle of action.

The principle of this machine is similar to that of the "Crosby" gage tester, that is, a known weight resting on liquid through a known diameter of plunger will produce a known pressure per square inch, neglecting the friction of the plunger in the cylinder. This friction is very greatly reduced by rotating the plunger, and in this instrument all danger of sticking under pressure is eliminated by the method described and patented by A. H. Emery several years ago of providing the plunger with a fine spiral groove.

This apparatus consists essentially of a cylinder and a piston rod provided with two plungers which fit this cylinder near its upper and lower ends. This rod carries a head, which in turn carries a tube to which is attached a platform which carries three annular weights, and by lowering this platform these weights can be successively placed on the tube and thus their weight transferred to the piston rod. The space around the piston rod, between the plungers, is connected with the leakage or "zero level" tank through a pipe provided with the valve *A*, and all leakage by the upper plunger also goes to this tank through the overflow pipe to the supply tank, and the oil is kept at a definite level in this tank and gives a uniform initial hydraulic pressure on the apparatus.

The hydraulic pressure is supplied by the two-plunger pump at the right, the plungers being driven by screws.



Diagrammatic view of instrument, illustrating the principle of action.

In use, if pressure less than 1,000 pounds per square inch is desired, the valve *B* is opened and the valve *A* is closed, in which case the hydraulic pressure operates on the whole area of the large plunger and the pressure obtained by letting on any of the weights is equivalent to the weight divided by the area of a 2½-inch circle, and in the apparatus as constructed the three weights shown each weigh 1,227.4 pounds and so give a pressure of exactly 250 pounds per square inch on the liquid, or a total of 750 pounds; the other 250 pounds being obtained by other means, as described later.

If higher pressure is desired, the valve *B* is closed and valve *A* opened, in which case the weights are carried entirely by the liquid under the smaller plunger, and as this plunger has exactly one half the diameter of the large plunger, the pressure will be exactly four times as much, or 1,000 pounds per square inch for each weight. To give subdivision of these loads and to be able to get a zero balance, the following arrangement is employed.

Two uprights at the left of the weights carry a lever through an "Emery" plate fulcrum, and the poise weights at the right can be lowered onto their platforms as desired, and their weight is carried to the plunger through a central stem, all the parts receiving the load through plate fulcrums. A slide weight gives still smaller increments of loads and the large weight balances the lever system and the piston rod, etc., so that when both the valves *A* and *B* are open the whole system is balanced with no load on the liquid.

By the use of these three sets of weights any pressure desired within the limit of the apparatus can be obtained to within one hundredth of a pound per square inch, and careful tests show that the apparatus is both accurate and sensitive to that amount.

Modern Research in the Metallurgy of Iron—II*

How Wonderful New Qualities and Properties Are Being Developed

By Allerton S. Cushman, Director, The Institute of Industrial Research, Washington, D. C.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2025, Page 259, October 24, 1914

Let us consider the names of some of the more prominent of these rare elements which research has introduced into the metallurgy of iron and steel, and review briefly what has been accomplished by their aid. Chromium, tungsten, vanadium, molybdenum, titanium, cobalt, tantalum—these rare elements have now their well-recognized place in the commercial exploitation of alloy steels. Steels containing, comparatively speaking, only very small quantities of these elements are made into tools which possess so-called self-hardening properties, and are known as "high-speed" tools. With such tools as these, enormous chips can be cut at high speed in heavy lathe and machine work. In many cases the tools can be used without oil and the chip and tool can safely be allowed to run almost red hot without damage to tool or work. Think of the economies in labor and time introduced by such a wonderful property as this. How can the influence thus exerted by these rare elements be explained? Becker tells us:*

"Carbon steel, as heretofore used in tools, no matter how well hardened, has not enough toughness and hardness to withstand the rubbing of the chip for any considerable length of time, even when not run fast enough to affect the temper. The tool therefore dulls; and this dulling proceeds in a sort of geometrical ratio as the cutting speed increases, being augmented by the drawing of the temper which accompanies rapid cutting. The speed in all metal-cutting operations has therefore had to be comparatively slow, no matter how powerful might be the machines in use. Thirty feet of chip per minute, as any machinist knows, has been considered rather good work; while 50 feet per minute has been very unusual. Under ordinary circumstances the management of a shop was pretty well satisfied if the machine tools could maintain an average speed of 20 to 25 feet per minute.

"Such deliberation, necessary though it has been, is depressing in this era. A creeping mass of metal turning leisurely round and round, or moving back and forth, as has been customary in the average shop, is quite out of harmony with the modern spirit of expedition and hurry. But while a few dreamed of the possibilities of cutting metal, some time in the future, with something of the vim with which wood can be cut; and while machines had been developed so tremendously as to leave scarcely anything to be desired in that respect, nevertheless the ultimate limit seemed to have been reached.

"But it had not."

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* Read before the Franklin Institute and published in the *Journal* of the Institution.

* G. M. Becker, *loc. cit.*, p. 6.

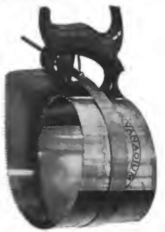

Fig. 8.—Vanadium steel saw which was kept coiled for four years and when unstrapped came out almost straight.

Fig. 6.—The Meigs Railroad leading up to the vanadium mines.

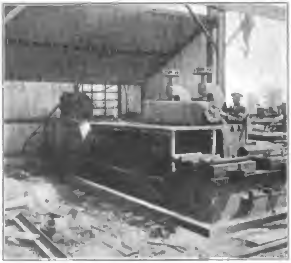

Fig. 14.—An ingot-splitting saw at work. As the ingots measure 18 inches by 20 inches or more in cross-section, this machine is very large and powerful.

Fig. 5.—The vanadium mines at Minas Ragra, near the backbone of the Andes.

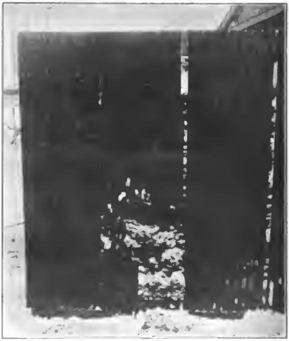

Fig. 17.—Illustration taken after eleven months' exposure in the box test, showing the failure of one type of sheet metal in competition with others.

In the review of the special constituents of steel, it was pointed out that certain extraordinary changes in the character of ordinary carbon steels take place, due to heat treatment through and about certain well defined critical points. The carbon-iron diagram shows that the hard constituents of steel are austenite and martensite, but if steels in which these constituents have been fixed by quenching and tempering are then annealed by high or prolonged heating, these constituents break down into the softer pearlite. Becker accounts for the influence of these rare elements as follows:[4]

"Tungsten acts first as a strong obstruction to all the steps in the change from austenite to pearlite, so that if we have 7 per cent or more of tungsten present, a moderately rapid cooling, even such as allowing the bar to cool in the air, will prevent the change to pearlite. Indeed, when tungsten steels are to be annealed and the pearlite stage produced, it is necessary that the cooling shall be very slow indeed, occupying several times as long as the annealing of normal carbon steels.

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[4] O. M. Becker, loc. cit., p. 40.

Fig. 7.—A group of llamas ready to transport the vanadium ore from the mines to the railroad.

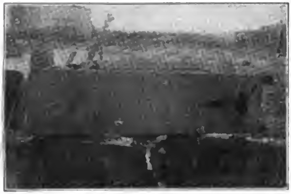


Fig. 12.—A longitudinal section of a piped ingot, showing great density and freedom from blowholes in the body of the metal.

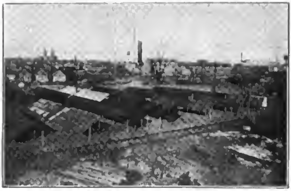


Fig. 15.—A view of the proving ground where full-sized commercial steel and iron sheets are tested by the author for corrosion resistance properties.

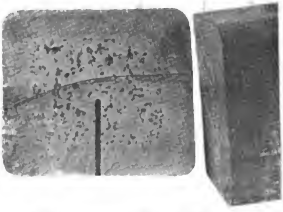


Fig. 10.—Cross-section, showing an open or spongy condition of a commercial steel ingot.

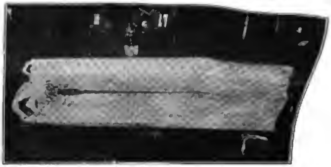


Fig. 13.—A longitudinal section of an experimental ingot, showing an extreme and dangerous form of piping.

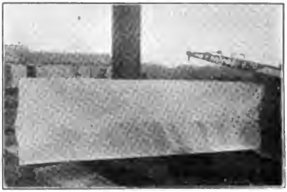


Fig. 11.—Longitudinal section of an ingot, showing improvement brought about as the result of careful research work.

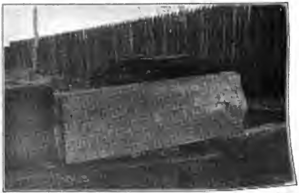


Fig. 9.—Longitudinal section, showing an open or spongy condition of a commercial steel ingot.

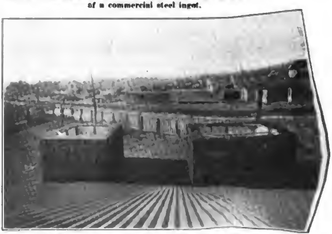


Fig. 16.—A new form of corrosion test. Hollow wall boxes built up out of test sheets and then filled with cinders or manure to accelerate corrosion.

"Tungsten acts, secondly, as a powerful fixing agent for martensite. It has been already shown that martensite is not stable in normal carbon steel even after it has been induced there by hardening, unless the metal be kept cool. Warming it up to the so-called temper heats changes the martensite over to troostite, and if the heating be continued, even the effective hardness of troostite is lost long before the steel reaches a red heat. The presence of 7 per cent or more of tungsten, however, increases the stability of martensite so much that the steel may be heated well above the tempering heats before the martensite even begins to break down into troostite or pearlite.

"Red hardness is the quality of hardness when at a red heat, and tungsten imparts this to steel under certain conditions, for a time at least. That is to say, we may cut with a tungsten steel at so rapid a rate that the point of a tool will reach that temperature where it almost begins to glow in a dark room, and still the steel will retain its hardness for many hours."

Vanadium, and vanadium and chromium together, are used to produce the wonderfully tough, anti-fatigue steels which are gradually supplanting all types of ordinary carbon steels in cases where very strenuous service is to be encountered, such, for instance, as in automobile and locomotive parts, and for springs of all sorts, which are more or less continually in motion. The extraordinary thing about vanadium is that less than two tenths of 1 per cent of this element is all that is usually necessary to confer upon steel this wonderful new property of resistance to fatigue. It is fortunate that this is so, for the principal source of vanadium is a vanadium sulphide ore which is painfully grubbed out of the sides and peaks of the Peruvian Andes, about sixteen thousand feet above the level of the sea. Fig. 5 shows the vanadium mines at Minas Ragra near the backbone of the Andes. Fig. 6 shows the Meigs Railroad leading part way up, constructed by Col. Meigs, the well-known American engineer. The ore is carried in bags on the backs of llamas to the sea coast, and eventually landed in the Pittsburgh district, where it is made into ferro-vanadium, an alloy of iron and vanadium, which, in turn, is used by the alloy steel makers in the manufacture of their special compositions. It is a curious thought that this rare material is found only in these apparently inaccessible places and then is carried upon the backs of llamas (Fig. 7), representing the most primitive form of transportation used in commerce, to find its special service in the manufacture of the most finished and developed means of transportation, such as the modern locomotive, automobile, and aeroplane. Fig. 8 shows a vanadium steel saw which was kept coiled for four years and when unstrapped came out almost straight.

Titanium finds its special use as a deoxidizer or purifier of molten steel, and it has been claimed that its use in small quantities produces great improvement in steel rails. The use of any element which claims to safeguard life by reducing accidents due to rail breakage must be watched with interest. Cobalt is the latest recruit to be enlisted in the making of high-speed steels possessing especially valuable characteristics. As cobalt is a by-product of the Canadian silver mines, an abundant supply for this purpose is assured.

Our time does not permit us to dwell longer upon the wonderful achievements of research as applied to metallurgy in the field of these special alloy steels. It has been the special province of the writer to investigate that region of iron metallurgy which lies at the other extreme. Thus far we have been mainly discussing the influence upon iron of carbon alone or together with the rarer alloying metals. In the manufacture of ordinary steels, a certain group of elements is always present as impurities. Some of these impurities are desirable, while some are present only because it has until very recently been found practically impossible to eliminate them on the large scale of operation made necessary by modern economic conditions. During the period of metallurgy which is comprised within the last century, men have been alive to the effects produced in iron and steel by the following elements which have often been referred to as the "big five." These are carbon, manganese, sulphur, phosphorus, and silicon. Owing to a peculiar condition of affairs that has arisen in the iron industry in America, we have now to add another common element of impurity, namely, copper, which changes the "big five" which the ordinary iron analyst is called upon to determine, to the "big six."

In 1905 the writer, who was then engaged in the conduct of certain research work in the United States Department of Agriculture, was called upon to make an investigation of the alleged extremely rapid corrosion of steel fence wire and other forms of steel used in agriculture. After a careful study of all the available sources of information, and an extended research inquiry in the laboratory, evidence seemed to be pointing strongly in the direction that a great improvement in many forms of steel would be produced if the five ordinary impurities then considered could be reduced or possibly completely eliminated. As the result of the publication of these researches and those of other workers in the same field, the electrolytic theory of corrosion was developed and is now commonly accepted as the explanation of the underlying governing principles upon which the rusting of iron and steel depends. In spite of its wonderful and useful qualities, ordinary impure iron and its derivative steel have the weakness of being easily attacked, not only by the moisture and oxygen of the air, but by all forms of acid action. The sources and ores of iron are all found in the highly oxidized condition, and iron is only won from this combination by the expenditure of enormous quantities of energy. Once divorced from its combination with oxygen, it shows a tendency to again unite with this element and thus return to its stable condition. One of the interesting and important fields for research, therefore, has been the study of this tendency toward oxidation and to devise ways and means of overcoming and, to as great an extent as possible, circumventing it. The electrolytic explanation of corrosion teaches us that the presence of the ordinary impurities in iron tends to stimulate the action and to throw the corrosive attack particularly upon certain points or nodes of an exposed surface, thereby producing that most dangerous form of corrosion, which is known as pitting or tuberculation.

It has already been shown that when a solution of salt in water is cooled toward the freezing point, it does not congeal into a homogeneous mass of salty ice, but a certain selective action takes place, resulting in a separation of the resulting crystals, ice, and salt. The same tendency exists when impure masses of mother metal cool down to the solidifying point. Some constituents crystallize out before others and become segregated. Segregation is one of the important problems that the modern research metallurgist is called upon to study, for it presents dangers from many different points of view if it is allowed to take place in an uncontrolled manner. If an ingot is segregated, the finished product of the ingot will be segregated and is liable to breakage or to corrosion damage, according to the nature of the product or the kind of service it is designed to endure. If segregation takes place as the metal cools and solidifies, the gases which are entrained or dissolved in the liquid bath cannot escape freely and therefore become entrained, producing an open or spongy ingot. Spongy ingots may be easier and less costly to bloom down than those which are solid and homogeneous, but there are, as the writer can testify, a number of honest and progressive manufacturers who are working to improve their ingots at the expense of very high cost in the maintenance of efficiently equipped research departments. It stands to reason that one way of overcoming segregation is to eliminate all alloying impurities, thus producing a pure iron in which there is nothing dissolved which can possibly segregate. The solution of the problem of producing such a pure iron on the large scale of operation demanded under the conditions of modern social economics and modern industry has been no easy matter. It involved from the beginning the doing of what contemporary metallurgists and metallurgical text-books stated it was impossible, or, even if possible, at best unwise to do.

The successful achievement of the results which are now obtained in the manufacture of pure iron on the large scale of open-hearth operation was not accomplished except as the result of very costly and strenuous research work in which determined men in the office, the mill, and the research laboratory joined forces with a common purpose and with loyal energy. The writer is proud of the share he has in this work and of the associations he has enjoyed with the group of men who have made it possible.

Where great strength is demanded, of course, pure iron is not suitable, but has many interesting properties which differentiate it from ordinary steels or alloy steels. Pure iron is very soft and malleable, and is capable of being most easily welded with the oxy-acetylene or oxy-hydrogen flame. A strip of this pure iron can be used as solder to join two ends or laps of the same material. It can easily be drawn into wire. Its electrical conductivity is 60 per cent better than ordinary soft or mild steel. The comparative resistance of copper being taken as one, that of commercially pure, so-called ingot iron is 5.3, of charcoal iron 5.4, of Norway iron 5.8, of soft steel 8. For this reason, this pure iron can be and should be substituted for steel in the manufacture of third rails in the electrification of railways. Every saving in the electrical resistance of the conductor is figurable into coal at the boiler end of the system.

In fact, this pure iron finds many interesting new fields of application, but its principal value so far has been due to its well known and well proven slow and even rusting quality. The writer has had comparative large scale exposure tests of various sorts and kinds under his observation for a number of years, and the pure iron seldom fails to give a good account of itself.

It has recently been claimed that ordinary steel alloyed with a little copper, say about 0.20 per cent, yields a metal of superior rust-resistance properties, and is therefore as good, if not better, than the purest iron. D. A. Lyon, speaking recently before this Institute,[*] voices this opinion in the following words:

" . . . the writer believes that there is more evidence to warrant the belief that the presence of copper in proper amounts in steel does prevent corrosion, rather than that it does not, or, as some claim, by reason of its being an impurity, promotes it."

I am one of those who do not agree with this opinion. It must be plain to everyone that even if in some respects, notably in conferring an added resistance to an acid test, the presence of a small quantity of copper is held to improve the steel, its admission as a basis of specification introduces a grave danger. Copper need not be, and generally is not, purchased by the manufacturer for introduction into steel, as it is much simpler to employ a cheaper grade of scrap as a material of manufacture, which contains the copper in the form of machine wastes. It seems inevitable that behind the screen of coppered steel specification will lurk the cheap segregated metals that modern research is trying so hard to work away from. Homogeneity and lack of segregation are the goal on which every progressive metallurgist has his eyes fixed, whether his special product is iron or steel.

Several recent lectures before this Institute have discussed the bearing and importance of the production of sound ingots on the iron and steel problems of the day. You have heard of piped ingots on the one hand, and of spongy, blow-holed ingots on the other. Between these two awkward extremes the conscientious steelmaker is struggling as between Scylla and Charybdis. To a limited extent, the metallurgist has the making of sound ingots under control, but much remains yet to be learned in this respect. Five or six different methods or experiments for meeting this difficulty have recently been brought forward, but there is no record that any one of them has as yet proved its universal applicability. The difficulties attending this line of research are very great, as may readily be recognized. Modern ingots in big practice usually weigh at least 5,000 pounds and are 18 inches by 20 inches or more in cross-section and 5 or 6 feet long. If we vary our metallurgical practice, how are we to tell whether we have made any improvement? The only sure way is to saw a number of selected ingot in two longitudinally, and thus open to inspection and study the center of the mass. Such operation is difficult, slow, and costly. Yet it can be done, and the writer is fortunate in having under his supervision an ingot-splitting saw so powerful that it will cut in two one of these huge masses in a few hours (Fig. 14). Directed by such instruments of research as this, progress is rapid, and great improvement in quality, both as to strength and rust resistance of product, is constantly being made.

The possession of this ingot-splitting saw has made it possible to study corrosion problems with special reference to the interior condition of the original ingot. After an ingot is split and has been studied, it is possible to roll down sheet metal into the full commercial sizes from the ingot and then put the sheets out under atmospheric and certain accelerated tests. By this means it is possible to follow up the problem in a more intelligent manner than probably has ever been done before. In the illustration in Fig. 15 a general view of the atmospheric corrosion proving grounds under the supervision of the author is shown, and it includes many hundreds of full-size sheets of many types, manufactured from iron and steel ingots.

An interesting test which has been devised, which although an accelerated test shows some very extraordinary results, is illustrated in Figs. 16 and 17. Large hollow-walled boxes are made of corrugated test sheets nailed side by side as panels, and the hollow walls are then filled with either cinders or manure. By this means it is possible to get results on resistance to corrosion, of experimental materials, in from six weeks to six months, whereas in ordinary atmospheric tests generally several years are necessary before decisive results can be obtained, upon which any definite conclusions can be built.

In spite of the extraordinary vigorous competition and difference of opinion in respect to the manufacture of corrosion resistant sheet metal, it is the desire of the writer to come at the truth of the matter through the methods of scientific research. A few years more of this sort of investigation work should furnish dependable data upon which to base conclusions. In the mean time, the various announcements made by special interests, in regard to corrosion resistance problems, should be accepted only in the spirit in which they are made—that of a desire to obtain the largest possible market for their own particular type of product.

[*] *Journal of the Franklin Institute, vol. clxxvii, No. 2, 192.*

Probably no field of metallurgical research is more interesting or more important than the development of special steels for use in the manufacture of high-power electrical machinery. We are facing, if we have not entered, the age in which electricity will be the great universal servant of man's evolution. The research metallurgist has been quick to respond to the call of the electrical engineer and designer for special types of iron and steel to increase the efficiency and lower the costs of dynamos and transformers. Time will not permit me on this occasion to discuss the contribution of metallurgy to this most important line of progress. There is material enough connected with the subject to call for a separate and special paper. It is interesting to note in passing, however, that it has been estimated, by a well-known electrical research engineer, that the metallurgical improvements in transformer steels, brought about within the last few years by modern metallurgical research, represents a saving in money which would amount, if capitalized at 6 per cent, to approximately $15,000,000 in the experience of one great manufacturing company alone. The writer knows that this claim is not exaggerated, and such statements stand for themselves when they are vouched for by those who are familiar with the data involved in making such calculations. No better argument than this could be advanced to justify the claim that modern scientific investigators are continually making, namely, that properly guided research work pays; that it is not a mere refinement or trimming on the edge of industry, but, on the contrary, is a business asset which should be set down at or near the top of the column when the cost of high grade production is being computed.

One more thought and I am done. Research work is not alone the servant of the producer. Its results ramify in every direction. It does not seek to cheapen the materials with which the human race is carving its destiny, by degrading them in quality, but it does cheapen them by seeking to improve the methods of their production with due regard to the end and object they are designed to serve. Scientific research work in a nation is a national asset which should be understood and encouraged by all the people. In this country we are only just beginning to realize the importance of development along this line. Something has been accomplished, but, in closing this paper, the deathbed words of a great man recur to my memory: "So little done! So much to do!"

Testing for Open Circuit*

Simple Directions for Locating Troubles in a Motor

By F. A. Annett

An open circuit in the field coils of a motor may produce several different effects, depending upon the condition under which it occurs and the type of motor. If series wound, the motor cannot start, for the field winding is in series with the armature, as will be seen by referring to Fig. 1, where the field coil *C* is open at *X* and no current can flow through the motor.

In the shunt motor the field and armature windings form two independent circuits; therefore an open circuit in the field coils will not interrupt the current flowing in the armature; see Fig. 2. In this type of machine a break in the field circuit may produce any of the following effects: The motor, if not loaded, will start if the brushes are not set at the neutral point. The direction of rotation will depend upon the setting of the brushes, but the motor will race and spark, and if an attempt is made to cut out all the starting resistance, the fuses will blow, or the circuit-breaker will open and there is likely to be burning at the commutator and brushes. If the machine is loaded, it will not start, and if the starting resistance is cut out, the fuses will be blown. With the brushes set on neutral, the machine will not start, but if they are given a backward lead, the armature will turn in the opposite direction.

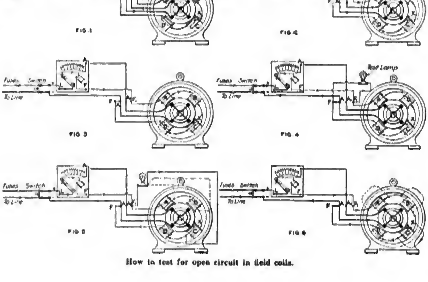
A simple method of testing for an open field where a shunt or compound motor has been operating properly and suddenly develops trouble is: First, disconnect the armature connection on the starting box, as shown in Fig. 3, and move the starting handle upon the first contact. If the field circuit is complete when the arm is allowed to drop to the off position or the switch is opened, a severe spark will occur at the contact; if the field circuit is open, there will be no spark. The break in the field circuit may occur anywhere from the first contact on the starting box around to the line connection on the motor. After determining that the field circuit is open, it is necessary to find out whether the break is in the motor, the external wiring, or the starting box.

A test may be made for a break in the external circuit by opening the armature connection at the starting box, placing the arm on the first contact, as before, and connecting a lamp across the field connection on the motor, as in Fig. 4. If the lamp lights, the field circuit outside the motor is complete, as indicated by the arrow-heads.

After it has been found that the break is in the field winding, inspect the connections between the field coils to see that none is broken or loose. After these are found to be in good condition, the defective field coil may be located as shown in Fig. 5. Place the starting-box arm on the first contact and connect one terminal of the test lamp to one of the field terminals of the motor; in this case F_1. With the other lamp terminal make connection between coils *A* and *B*, as indicated by the dotted line. In this position the lamp will not light, for the circuit is open at *X* in coil *C*. Next connect the free lead of the lamp between coils *B* and *C*, also indicated by the dotted line; again, it will not light. However, when connection is made between coils *C* and *D*, as shown by the solid line, the lamp will light, for now the open coil has been bridged. Since the lamp will not light between coils *B* and *C* but will light between coils *C* and *D*, it shows that coil *C* is open-circuited. Where a test lamp is not at hand, a piece of wire may be used to bridge one coil at a time, as shown in Fig. 6. First, short-circuit one coil as indicated by the dotted line at *A*, then close and open the switch. If a spark occurs when the switch is opened, the open coil has been bridged. In this case, however, it does not occur until coil *C* has been short-circuited, as shown by the full line. After the open coil has been located it should be disconnected and again tested through with a lamp to be absolutely sure that it is defective.

The open circuit often occurs where the leads are connected to the coil winding; this may be easily located and repaired. After the coil has been opened up it should be tested back of the splices where the coil connects to the leads to make sure that the trouble is in the coil itself. In many cases, especially where the coils are not wound on a spool, the open-circuit can be located and repaired without rewinding the coil, for if not found at the points mentioned, it usually can be located in the coil itself by a burned spot on the insulation caused by arcing when the coil opened.

An open-circuit in the shunt field of a compound motor will have practically the same effect as in the shunt motor, except that the motor will usually start whether loaded or not, as the series field will provide sufficient torque to start under full load, but the machine will usually race in either case. The break in the shunt field may be located in the same manner as described for the shunt machine. An open-circuit in the series field will cause the machine to fail to start in the same way as described for the series motor in Fig. 1.



How to test for open circuit in field coils.

Radioactivity of Mineral Waters

The radioactivity of mineral waters has attracted much attention during the last decade, and it is now widely believed that the therapeutic value of many waters is largely due to their content of radio-active substances. For many years the beneficial effects attending the use of certain natural waters were attributed to the common mineral ingredients determined by chemical analysis, and several elaborate systems have been devised for classifying such waters on the basis of their chemical composition. Though many natural waters unquestionably cause physiologic reactions because of their great content of common mineral substances, a large proportion of the well-known waters of the United States do not differ essentially in concentration and composition from supplies of city water used daily by thousands of people without apparent physiologic reaction other than that following the use of water itself. Tests have shown that many of these slightly mineralized waters have various degrees of radioactivity, and consequently, as radium compounds have been found to cause marked physiologic reactions, the improvement in health following sojourn at springs has very naturally been attributed to the radioactive properties of the waters. There are yet too few experimental data to settle this point definitely, but it is perhaps not out of place to call attention to the facts that in radiotherapy as in all other branches of medicine the curative agent must be present in a certain strength in order to exert any healing influence, and that most of the radiotherapeutic reactions thus far investigated have been effected by means of radioactive compounds whose strength is far greater than that of natural mineral waters. Therefore owners should not be led into making strong claims for the radiotherapeutic value of the waters of their springs without careful investigation of the subject.—R. B. Dole in *Mineral Resources of the United States*, 1913, Part II: 24.

Quick Track Repair Methods

When a trolley track is to be repaired in a city, or any other considerable work is to be done, a great deal of time is lost, and the street is obstructed for a longer time than necessary, by the slow present process of pulling up and removing the pavement between the tracks. An up-to-date method of procedure has been adopted in Cleveland that greatly facilitates the work and saves considerable time as well. A special heavy cast steel plow, of suitable shape, which, with its car and weighting weighs eleven tons, is hauled by a powerful service car and rapidly breaks up and lifts any granite pavement, and at the same time cuts the track tie rods. With this equipment a crew of three men can break up 1,300 square feet of pavement a minute.

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* From *Power*

The Electrically-Driven Gyroscope in Marine Work—II*

The Toy of Yesterday Now a Valuable Scientific Instrument

By H. C. Ford

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2025, Page 269, October 24, 1914

A most important use of the gyro compass is on submarine boats which derive their power, when submerged, from storage batteries, the voltage of which varies at times from as high as 130 volts down to 100 volts at the end of a long run. An economical form of voltage regulator has been devised for such service.

The problem of accelerating and driving the heavy balance wheel (the compass wheel weighs about 45 pounds or 20.4 kilogrammes) at a velocity of about 8,600 revolutions per minute required the design of a special form of generator, three-phase current at 90 volts being used. The characteristics of the generator allow of the wheel being thrown directly upon the line and brought up to full speed automatically in about thirty minutes without attention on the part of the operator and without the use of excessive current. This machine, shown in the background of Fig. 10, has a capacity of three amperes per phase, but is ordinarily run under a load of 0.9 ampere.

The 20-volt direct-current dynamotor also shown in Fig. 10 is used in supplying energy to the servo motor follow-up system and for operating the secondary or repeater compass system. No special features of design were necessary other than to meet the usual requirements on shipboard as to commutation, rating, accessibility, etc. In battleship equipments, both of the above generating units are ordinarily supplied in duplicate.

An emergency direct-current service is provided by the employment of a 20-volt storage battery which is kept floating upon the line at all times. This provides energy for operating the follow-up system of the compass whenever the ship's service has failed. During such times the gyro wheel, on account of its great inertia and ease of operation in vacuum, will remain spinning and will give ample directive power for an hour or more after the power has been shut off, so that the compass is rendered fully effective under all such conditions. This constitutes a unique and extremely valuable feature of the Sperry compass.

An independent six-volt battery and alarm bell are employed to notify the attendant promptly of any interruption of current or failure in operation of various parts of the system which would be likely to cause errors in the compass readings, so that the same may be corrected without delay. A trip relay is provided which keeps the bell ringing until the attendant has corrected the difficulty and reset the trip.

A reverse current relay is provided for disconnecting the direct-current dynamotor from the storage battery and line upon failure, or any material reduction in voltage of the generator or ship's supply line, and for connecting the generator in again when voltage has been restored to normal. This, of course, prevents the rapid discharge of the storage battery in driving the generator.

Especially designed switches and controlling apparatus are provided, which include a small and compact switch for throwing both the voltmeter and ammeter at once upon any one of a number of different circuits or phases. These switches are of the rotary or controller type and are inclosed in gas-tight cases to prevent danger of explosions when used in submarines.

The gyro motor is of the three-phase induction type, the squirrel-cage secondary forming a rigid part of the inner rim of the revolving wheel shown in Fig. 11.

On account of the high speed of the rotation, wheels have to be given a very careful running balance, which is accomplished by the use of various size studs threaded into holes at the periphery of the wheel on each side.

The stator also shown in Fig. 11 is mounted on one side of the main vacuum casing containing the wheel. A spiral line is painted on the wheel which, when observed through a window in the casing by means of a stroboscope, enables one quickly to determine the speed of rotation.

The servo motor or follow-up system forms an important part of the gyro compass and performs three functions, of which the first is to shield the gyro from all external forces and friction. This is accomplished by the method of carrying the supporting filament, and all guiding bearings having to do with the sensitive element, within an outer frame known as the phantom (Fig. 12), which completely shields the element from all disturbing external forces.

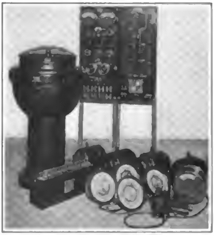

Fig. 10.—Complete equipment for a gyro compass installation on a battleship.

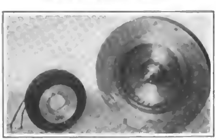

Fig. 11.—Rotor and stator of the gyro motor.

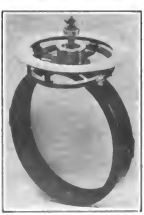

Fig. 12.—Power-driven frame or "phantom" arranged to shield the directive element from external disturbances.

The suspended mass of the sensitive element, which, including the wheel casing and the vertical supporting ring, weighs about seventy-five pounds, is by the above means rendered actively sensitive to a force couple of 1/4,500 inch-pound, which represents a force of less than one-four-millionth part of its own weight acting at a radius of one foot. This degree of sensitiveness is actually measurable in the operation of the compass, which is thought to be somewhat remarkable in this respect.

A second function of the servo motor, which in the gyro compass is known as the "azimuth motor," is to operate the transmitter for sending out indications to any number of repeater compasses located at distant parts of the ship. The main azimuth scale of the compass is also carried on the power-driven member.

The third function of the azimuth motor is to operate the correction device before mentioned, which by means of cams solves a trigonometric equation involving the factors of speed, latitude and heading of the ship, and automatically introduces the proper correction into the compass readings, which are therefore maintained accurately upon the meridian. Fig. 13 shows the front of the correction device and dials which are set at the proper speed and latitude.

The azimuth motor with its reduction gearing is shown in Fig. 14, and is provided with ball bearings throughout. An inertia brake consisting of a balance wheel mounted and driven by friction on the armature shaft serves to damp the oscillations or hunting of the azimuth motor, while offering no resistance to continuous motion.

The secondary transmission system comprises a contact making transmitter and six-pole step-by-step motor connected by three circuits having a common return wire. The transmitter (Fig. 15) is provided with three pairs of tungsten make-and-break contacts which are operated by cams. The construction of the repeater system is such that the motor may be driven at speeds as high as 1,000 revolutions per minute, or 100 cycles per second, without getting out of step.

The repeater motor is geared to give six steps for each indicated degree in azimuth and the repeater compass instantly follows all changes of the master compass for every movement of the ship. The repeaters are provided with compass cards made of translucent material to permit of illumination from within.

A manually operated transmitter, or synchronizer, is used for setting the distant repeaters into agreement with the master compass in connection with a magnetic stop for each motor, by means of which the repeaters are first collected upon a common reading and then brought at once to read with the master which is then thrown into circuit.

The exceptionally fine results obtained with the gyro compass here described have fully justified the long and painstaking efforts that have been expended in its design and in the practical solution of the many problems met at various stages of its development and in actual use at sea.

When subjected to the most drastic tests, far greater in severity than any actual conditions found on shipboard, the compass continues to hold to the meridian within a fraction of a degree. In fact, every compass before being accepted by our government has to pass through a series of such tests lasting several weeks, during which time the maximum error must not exceed ½ degree in azimuth when swung continuously for six

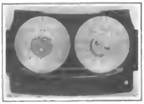

Fig. 13.—Automatic correction dials. Setting 15 knots, 40 degrees north latitude.

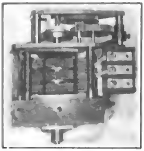

Fig. 14.—Azimuth motor for driving the phantom.

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*Paper read before the American Institute of Electrical Engineers and published in the *Proceedings* of the Institute, vol. 33, No. 6, p. 873. Copyright 1914, by American Institute of Electrical Engineers.

days at a time under conditions of rolling, pitching, and yawing of an artificial ship.

It should, of course, be understood that under similar conditions on board a battleship or submarine the magnetic compass would be almost, if not entirely, useless. Even under the best of conditions, navigation of a steel ship by magnetic compass entails a large amount of extra work with considerable liability of error in applying variation and deviation corrections of various amounts, plus or minus. With the gyro compass described, all readings are made exactly upon the meridian and the navigator is always sailing on true courses. The quick and accurate indications of the compass for the slightest deviation or yawing of the ship have enabled much straighter courses to be steered, with a resulting saving in fuel and increased speed. For intricate maneuvering in battle practice, the ship may be controlled perfectly from various protected steering stations, and the master compass is completely shielded from the fire of the enemy and from the shock of gun fire.

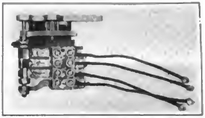

Fig. 15.—Transmitter for operating secondary or repeater compasses.

In submarines the gyro compass enables an accurate course to be laid when running submerged, so that after obtaining the bearing of the target from a great distance the submarine may approach, submerged, to within a short distance and fire its torpedoes accurately.

From an instrument having a degree of sensitiveness to force couples measured by one-four-millionth part of its own weight it is rather a long jump to consider another type of gyro possessed of many tons of stored energy which may be harnessed and made to work not only to hold a mammoth ship against rolling in high seas, but actually to roll the ship for the purpose of sliding off a sand bar or breaking through an ice flow.

Gyros of this type have already been built, tested, and thoroughly investigated, and a gyro of thirty tons weight, capable of exerting a force couple of over four million pound-feet, is now under construction for stabilizing the steamship "Ashtabula," used as a car ferry on Lake Erie.

In two papers read before the Institute of Naval Architects and Marine Engineers in November, 1912, and December, 1913, Mr. Sperry has treated very ably and comprehensively the subject of stabilizing ships, and has made some striking comparisons which show his valuable contribution to the art in the "active" type of gyro. In the last paper referred to are shown characteristic rolling and damping curves for ships equipped with active gyros when subjected to various wave impulses and frequencies. These curves, some of which are here reproduced in Fig. 16, were obtained from a model ship pendulum, the dimensions of which were adjusted to correspond to a 19,000-ton ship at the linear ratio of 1. 30.

The stabilization is practically complete, as indicated by the curves in Fig. 16. Early in this work observations were made indicating that the stabilization was complete even when the wave increments received from the sea were greater than the theoretical power of the gyros mounted in the ship.

The work with the stabilizer has shown that it is perfectly easy to stabilize against all wave increments received by the ship from the sea which are equal or less than the stabilizing capacity of the gyro equipment. Stabilization is so complete under these conditions that interest in this part of the performance has been transferred to investigations of the region where the wave increments are actually in excess of the stabilizing capacity.

The curves in Fig. 16 are among the results obtained in this connection, and it will be seen by carefully scrutinizing the cards that none of the curves are taken where the wave increments are not larger than the roll-quenching increment, and even under these conditions the stabilizing is practically complete for practically all the wave periods.

Practical data of great value were obtained from the construction of an active gyro plant which was tested out repeatedly on the U. S. S. "Worden" during the summer of 1912. This plant was the largest gyro installation ever built and consisted of two gyros weighing about three tons each which were operated actively by use of a precession engine.

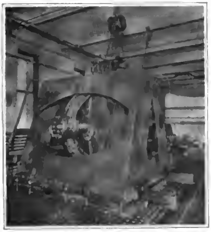

Fig. 17.—One of the two large gyros of the U.S.S. "Worden" while under preliminary tests at the Navy Yard, New York.

The gyros were automatically controlled so that they responded instantly to all wave increments encountered, whether in harmony with the period of the ship or not.

Fig. 17 shows one of the "Worden's" gyros bolted on a heavy base plate while under test at the Brooklyn Navy Yard. The base was loaded with pig iron, which, with the load of the gyro and precession engine, brought the total weight up to over thirty tons. The gyro very effectively demonstrated its power by actually lifting this heavy load, tilting the whole base plate up on edge and rocking it back and forth as the gyro was precessed.

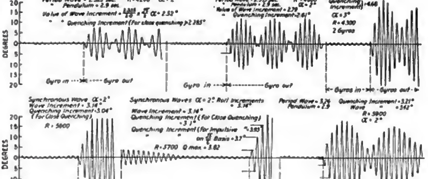

Fig. 16.—Curves showing stabilizing capacity of gyro when wave increments are excessive.

Fig. 18 shows the precession engine.

The results prove conclusively that the active type of gyroscope as applied to the control of a ship's rolling motion is of vastly greater efficiency and economy than any other form of stabilizer yet proposed. The efficiency is demonstrated by the action of carefully calculated scale models and is completely verified by the long-continued performance at sea of the gyro plant on the "Worden." The economy is evident from a comparison of the space and weight required in an installation of the active gyro relative to that required by the most effective form of water damping tanks or other stabilizing means.

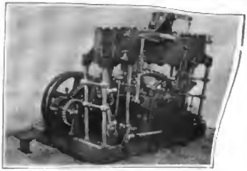

Fig. 18.—The precession engine.

Careful calculations show that an active gyro plant for stabilizing the steamship "Ashtabula" will require less than one tenth the space and weight which would be necessary for equivalent stabilizing with the best designed water pendulum.

The results further show that it is now possible to completely stabilize any ship against rolling by means of an active gyroscope, requiring a very small percentage of the weight and space available in the ship. This work has opened up a wide field of usefulness in the application of the gyroscope, and its application to passenger vessels will be watched with interest.

Photo-Electric and Photo-Chemical Action

The experimental complexity of the relations between the number of emitted electrons and stimulating radiation makes advisable a wide basis for a theory of these actions, and an attempt is made by O. W. Richardson, in a paper read before the American Physical Society at Chicago, to develop such a theory on the basis of the energy abstracted from radiation in liberation of an electron or atom, and since the argument is unaffected by existence of change the term "atom" may be taken to include ions and electrons. The fundamental equation obtained involves the assumption, as yet not tested experimentally, that the number of atoms emitted by a given amount of light is the same whether light is or is not decomposed, without energy loss, into its spectral constituents, which is the simplest assumption consistent with photoelectric evidence that the number of emitted electrons is simply proportional to the intensity of light of definite spectral composition, but varies greatly for equal energies and for different frequencies. It is also assumed that: the distribution of energy in the radiation is given by Planck's formula; that photochemical actions are fundamentally independent of temperature at low temperatures, as is indicated by the experimental evidence, and that they do not contravene the second law of thermodynamics; that the contribution of the radiation to the mean internal energy of the emitted atoms, i. e., their kinetic energy in the condensed form, is negligible.

This last assumption is a very real restriction of the theory, which it makes essentially a provisional one, since the whole of the internal energy of the atoms might quite possibly arise from the radiation. The fundamental equation is then shown to lead to the conclusion that $\phi(\gamma) = h\gamma$, where h is Planck's constant, and $\phi(\gamma)$ is the mean energy which each atom, liberated under the influence of monochromatic radiation of frequency γ, has acquired from the radiation at the moment of liberation. It is then further shown that a consistent scheme of relations may be framed whereby this equation may hold good at all temperatures. In comparing the scheme so formulated with experiment, it must be remembered that the neglect of the part played by electron reflection in the electrical case, and by corresponding atomic deflections in other types of photochemical action, although not affecting the equilibrium values, will affect photoelectric results dealing, not with a state of equilibrium, but with the rate of emission under a given illumination.

Nodon Electrical Process

For Rapid Drying and Preservation of Wood

FRENCH technical journals are interested in the process invented by Albert Nodon for the rapid drying of wood by means of electrical currents, which at the same time are a preservative agent and a destroyer of germs of whatever nature that may be within the wood. Nodon's first researches with reference to lumber date as far back as 1900, when he devised a process for "ageing" wood, but it involved complicated and costly technique and proved to be not always practicable. He has, during the intervening time, engaged in long and careful researches, and now* describes his method, of which he claims the action is regular and certain.

The action of electricity upon wood he notes to be triple in character: chemical, physical, and aseptic. The chemical action consists principally in the complete and rapid oxidation of resinous matters, the physical action results in molecular changes in the cellulose which modify its mechanical properties and tendency to decay, while the aseptic action consists of a complete and definite destruction of all parasites and agents within it acting for dissolution.

Wood is a living substance and is prey to destructive organisms, largely inherent, as soon as it is felled. Preserving processes are therefore of greatest interest and value. The problem is complex, and for that reason the methods usually employed are incomplete and insufficient. It is necessary to a process that shall be successful that it be simple and inexpensive, and that it be practicable not only in permanent mills, but even at the place of the lumber operations. It should be equally applicable to logs and to lumber, uniform in its action, and should not be of a character to interfere with drying in the open air. It is claimed by Nodon that wood dried by his process no longer shrinks and swells with the weather and that its strength is in no way impaired, but on the contrary is somewhat increased by the operation. Its limitation is set at peeled logs, especially if partly dried, for these no longer retain sufficient moisture to conduct the electric current.

Drying of Wood.—One of the most important industrial questions with lumber is its rapid drying. As the industries consume ever-increasing quantities of stock, and the number of trees is constantly diminishing, the result is that it can no longer be kept in the old-fashioned way till it is properly dried. The industries chafe at holding idle the capital necessary for such vast quantities of material, and kiln drying has therefore pretty generally replaced the natural method.

Unfortunately kiln drying has its defects. The desiccation is often only superficial and the wood afterward absorbs moisture with avidity when it has the opportunity. The presence of the sap opposes itself to kiln drying, and methods of getting around this difficulty by steam at high temperature and pressure are not very satisfactory. Such a process, moreover, is an injury to the lumber, and affects its life, strength, and durability. Under the heat and moisture the cellulose and its derivatives begin a change into dextrine and glucose. There is truly no comparison between the kiln dried and the naturally dried stock, and in addition the injury that haste causes is at the further cost of expensive heating plants and continually increasing price of fuel. All these factors have joined in raising the price of lumber.

Nodonization, on the contrary, secures in a very short time the oxidation of the sap which would be accomplished slowly in the air, and it changes various materials within the wood into resins. The oxidizable content of the sap has great hygroscopic qualities, and when dried in the kiln seizes moisture when it can, but transformed into resins it loses this appetite, or rather thirst. It is such oxidation that gives to the natural process of drying its evident advantages. But in thick logs or lumber the process is exceedingly slow. The electrical current is able to accomplish in a short time a work more complete and uniform than would years of open-air drying. Nodonization is a process in which electricity acts on the sap and puts the lumber into a condition where a short supplementary outdoor exposure will dry it thoroughly, while logs felled at the same time but not treated will yet be hardly dry on their surfaces. Even in trees that have been cut for some months the electricity will secure results if only there be retained sufficient moisture to insure conduction. Trees may be treated immediately after cutting and thereby be protected from any possible deterioration.

Preservation of Wood.—A part of the process that is set forth by Nodon is that the current completely and rapidly oxidizes and turns into resins many of the materials in the wood such as albuminoids, gelatins, glucoses, and tannins. At the same time the current has a microbicidal effect on all living germs that the green wood incloses, which are ordinarily the cause of the rapid destruction when the wood is finally exposed to air and moisture. There are many agencies of ferment and destruction within the wood cells—starches, sugars, diastases, etc., besides proteids, albuminoids, and nitrates, which are easily changed. The process of decay is outlined by Nodon, who notes, in addition, that there are yeasts, mosses, and fungi that bear their part in the destruction of the wood. The tree has in it while living the causes of its future decay, and as soon as its vitality is weakened these begin to act, especially in the presence of heat and humidity.

Nodon's process, he claims, destroys all the germs and parasites, large like some of the fungi or microscopic in size like the bacteria, which are already in the lumber, while it so transforms the material of the wood as to make it resistant to decay-germs from the outside. Treated wood likewise resists the attack of insect destroyers which do not here find their suitable environment.

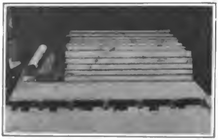

Fig. 1.—Pile of timber ready for the Nodon process. Cylinder at left, a mat-electrode rolled for carrying.

Practical Application of the Electrical Process.—The method of Nodon is illustrated in Figs. 1 and 2. Both diagrams show the method of piling wood in layers separated by mat-electrodes, which afford a means for the application of the current. Such mats, the section of which is shown in Fig. 2, are flexible and may be rolled into a cylinder about a stick after the fashion of ordinary house rugs. Fig. 1 shows to the left a mat-electrode thus rolled. The mats are made up of a flexible web of galvanized iron between two thick jute coverings. They are good conductors of electricity when wet and are spread between the layers of lumber.

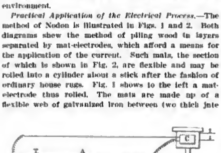

Fig. 2.—Pile of lumber ready for treatment. Below, section of mat-electrode.

C, switch-box; *B*, *B'*, poles connected with alternate mat electrodes, E; *T*, lumber; *m*, flexible metal web; *t*, *t*, jute cloths.

When the drying process is conducted in a factory or mill it is easy to arrange a platform on which to lay the first mat, then comes a layer of green wood, dimension stuff, planks, girders, joists, and the like. The pile is built up of alternate mats and layers of wood until it is from three to five feet in height, the mats being well moistened. Alternate mats are connected to opposite poles, and the process begins. The current will then traverse individually the layers of wood and the resistance will be the minimum. The electricity passes through the wood in the direction of its smallest dimension.

The conductivity of the lumber is very different, according to the kind of wood, its thickness, the degree of humidity, and the season when it was felled. The resistance may vary from 6 to 20 ohms per cubic meter (one cubic meter = 35 cubic feet), and to circulate a current of 5 to 6 amperes through a cubic meter of wood in the form of joists, an electromotive force of from 30 to 100 volts will be necessary. The resistance of a pile of lumber thus placed remains constant through a treatment.

An alternating current should be used by preference; 40 to 50 cycles at 110 to 120 volts is suitable, although it is better to use a lower frequency, 15 to 25 cycles, and a lower voltage. It is, of course, practicable to adjust the electromotive force by means of resistance. It is possible to use the direct current, but at a disadvantage, for it produces electrolysis that destroys the mats. Such a current of 110 volts is suitable, but it is necessary to reverse it by hand from time to time.

Treatment in the forest is effected with great advantage when the wood is in the sap in the summer, for then it presents its maximum of vitality for industrial purposes, and it is also the most favorable season for drying in the natural way. Piles of wood with their mats can be disposed at the place of felling, and the treatment may be continued day and night. When the treatment is finished the lumber may be piled in suitable places near by, and the drying completed naturally and in the space of a few weeks. Treatment in the woods is economical since power is cheap, and the great costs of transporting sap and waste are avoided. The time of treatment varies from one to two full days, according to the nature of the wood and the results desired. Wood, if treated too rapidly, develops cracks and flaws, although its strength is the same as with the slower process. The treatment varies also, according to the purpose of the wood, it being desirable to regulate the current to from 4 to 5 amperes for the arts like cabinet work, furniture or finish, while when it is for rougher uses like girders and joists, paving blocks, or railway ties, the current may readily attain 10 amperes.

The total current that a cubic meter of wood should receive should be about 150 ampere-hours. It makes little difference if the operation is suspended at night, it being simply necessary to keep the mats wet, so that the resistance of the wood will not increase. Wood in the sap does not require above 40 volts, but logs in the bark may need from 80 to 100 volts.

Costs.—The cost of a plant of this kind is merely that of the mats and of the electrical plant and running. The price of mats is low, about 80 cents (four francs) a square meter, and for mats enough to treat a cubic meter of wood a day about $8. The mats will last a year if properly cared for. The depreciation is therefore about two cents a day per cubic meter of wood.

Comparisons made by Nodon of costs in the factory and the forest are given, the latter being much the smaller since there is less to pay for fuel, for handling, and for transportation.

FOREST.	
Current, 3 kilowatts at 1.2 cents	$0.04
Handling and transportation	.40
Depreciation	.10
Total	.54

FACTORY.	
Current, 5 kilowatts at 3 cents	$0.15
Handling and transportation	.50
Depreciation	.12
Total	.77

With reference to industrial applications, Nodon gives some local facts. Wood so prepared is useful in the ordinary ways of building, finish, furniture, ships, railways, ties, paving, etc. In France there is much imitation mahogany. It arrives from Africa in a few days after cutting in great logs filled with sap, and the treatment of these in the kiln has not been very successful. Wood paving has been little used in the country on account of the high cost compared with durability. Bordeaux has approved the Nodonized pavements, and Paris is now testing them in some streets of important traffic. It is well, according to Nodon, to treat the paving blocks while warm in a bath of waterproof liquor like creosote or tar and to cover them with a protecting layer. This will keep the pores closed, for even with its advantages the Nodonized wood is not stone.

If processes for preserving woods are to be adopted, they must be forced on the producer by the consumer, as the timber owners prefer present high prices without regard to the requirements of the future.

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* From *Le Génie Civil.*

Superheaters on Locomotives

It may be said that, with possibly the exception of the Glasgow and South-Western Railway, there is not a single important railway in the British Isles that is not now using superheaters for locomotive work, a truly remarkable instance of the rapid adoption by locomotive engineers of progressive ideas, seeing that only a few years ago the superheater was practically unknown on the railway.

British engineers, however, are not alone in thus speedily recognizing a good thing. Of that fact there was ample evidence at the recent Paris meeting of the Institution of Mechanical Engineers, particularly in the paper by Professor Edouard Sauvage on "Recent Development of Express Locomotives in France." According to the professor, with the exception of some Atlantic type locomotives—which are not likely to be reproduced, by the way—all engines built for express work in France during the past decade are six-coupled, being either ten-wheelers (4-6) or Pacifics (4-6-2). On these superheated steam is largely used, with a few exceptions, the Schmidt standard superheater being the type generally adopted.

With regard to this increasing use of superheaters, Professor Sauvage makes the interesting comment that owing to the large tubes necessary to receive the superheating pipes, it frequently happens when a superheater is fitted to a locomotive boiler that the proper heating or vaporizing surface is greatly curtailed; in fact, in many engines the total of the heating and superheating surface is less than the heating surface that might have been obtained without superheating.

Without superheaters the heating surface equals 72 to 77 times the grate area in engines having narrow fire-boxes, and 60 to 62 times in the case of wide fire-boxes. With superheaters the ratio of proper heating surface to grate area is as low as 50, and does not exceed 60. Although the results in service are good in all cases of superheating, this large reduction of heating service can hardly be regarded as entirely satisfactory.

No difficulty is reported to arise from the use of superheaters. They are found to be easily kept in order, and valves and pistons, when properly lubricated with an efficient oil, do not give signs of undue wear even with a high superheat—up to 340 deg. C.

Except in the case of one French company, all engines for express service have four cylinders, with a large proportion of compounds. In a few cases simple expansion, in four equal cylinders, is used, but the compound system appears altogether to be preferred. The one exception is the recent building of the Midi Railway for express purposes, of simple engines with only two cylinders and using superheated steam. Of course, simple engines on this principle exist on other railways, but they are not used for fast service.

When superheaters have been added to the four-cylinder compounds, the diameter of the high-pressure cylinders has been increased, the low-pressure cylinders being left unaltered. Piston valves are generally used on all cylinders, even on non-superheaters, but in a few cases, for instance, on Paris-Orleans engines, flat valves have been preserved on the low pressure cylinders of superheaters.

Other systems of superheaters besides the Schmidt have been experimented upon. At first, for fear of overheating the high-pressure cylinders, superheating in two stages was resorted to; high-pressure steam being moderately heated, receiver steam being passed to a second superheater. This plan, Professor Sauvage records, has been abandoned. A helical superheater, on the principle of the field tube, with ribs, was fitted to some engines, and was abandoned on account of its insufficient surface and of the difficulty of cleaning its outside ribs. Another system tried is known as the Mestre "squirrel-cage" superheater, this is working on some engines, and gives ample surface.

On the French railway—the Nord line—the engineers speak most favorably of their superheaters, and they agree that to get the best results superheating must be combined with compounding, a system which is to be adopted in future locomotives. It is found that with steam temperatures of 300 deg. to 340 deg. C., no undue expenses for repairs have had to be met. As regards actual working experience, we have the testimony of the chief engineer of the Nord Railway, M. Asselin, who advised Professor Sauvage that "until 1904 our fast engine was an Atlantic without superheater, a four-cylinder compound with a horse-power of 1,400 (1,380 b.h.p.). The first step was to increase the power of these Atlantics by the addition of a superheater. Although taking heavier trains, these engines with superheaters showed an economy of at least 5.3 lb. of coal per mile. The second step was to build Pacifics of about 1,900 h.p. (1,873 b.h.p.). It is remarkable how economical these engines proved. With the same weights they consume practically the same quantity of coal as the Atlantics with superheaters; and with the heavier loads than the latter could manage without superheaters the Pacifics burn less coal."

Other valuable comparative data were collected by the chief engineer of the Paris-Orleans railway, who made an interesting comparison in actual running of twenty Pacifics without and of fifteen with superheaters. The mean coal consumption per 100 ton-mile was in winter (including steam for heating the trains) 13.8 lb. for engines without superheaters, and 12.4 lb. in the case of engines with superheaters. A saving of no less than 10 per cent. is thus shown to exist in favor of the superheat. Thanks to superheating, it can be placed on record that in a period of fourteen years, during which the weight of trains on the Nord Railway has been doubled, the coal consumption has remained practically stationary, and it is much the same story on many other lines.

But, as has been pointed out by those eminent English locomotive engineers, Messrs. J. A. F. Aspinwall and G. Hughes, the coal bill is only one item of expense in locomotive working, although the rise in the price of coal makes it more and more important; the economy of first cost in the case of two-cylinder simple engines must be taken into account.—*The Daily Telegraph.*

Explosive Mixtures of Gases*

An explosion is essentially a very rapid combustion which occurs almost simultaneously in all parts of a mass of combustible substance. The heat developed by the combustion raises the gaseous products of combustion to a very high temperature, and gives them the enormous pressure and expansive tendency which produce the destructive effects of explosives.

In order that combustion shall be almost instantly propagated throughout a mass of gas it is necessary that the air required for combustion shall be intimately mixed with the combustible gas, and in order to attain the high temperature requisite for explosion the mixture must not contain a large quantity of gas that takes no part in the combustion, for such a mass of inert gas would exert a cooling effect. This consideration leads to the law, which is confirmed by experience, that mixtures of combustible gas with air are explosive only when the percentage of combustible gas in the mixture lies between certain limits. These limits, for some important gases and vapors, are given in the following table:

Gas or Vapor.	Percentage of Gas in Explosive Mixture.	
	Upper Limit.	Lower Limit.
Hydrogen	66.4	9.45
Illuminating gas	19.1	7.9
Methane (marsh gas)	12.8	6.1
Alcohol vapor	13.65	3.95
Ether vapor	7.7	2.75
Benzin vapor	4.9	2.4

The explosive limits, however, are dependent to some extent upon the size and shape of the containing vessel and upon the character of the ignition (strong electric spark, weak spark, or flame).

It will be observed that the proportion of combustible gas required to form an explosive mixture with air is very small, except in the case of hydrogen. Explosion may be caused by the presence of less than 3 per cent of ether or benzine vapor in the atmosphere. In general, however, the danger of explosion is proportional to the range of explosiveness, i. e., the difference between the upper and lower explosive limits, and is consequently greatest in the case of hydrogen.

The danger of explosion can obviously be averted by preventing the mingling of the combustible gas with air. The idea, still widely prevalent, that certain gases are explosive in themselves, is erroneous, as was proved in a very striking manner by Samuel Clegg at the installation of the first gas-house in London. To the consternation of the examining commission Clegg bored a hole in the wall of the gas-holder and ignited the issuing stream of gas. A long flame shot out, burned quietly, without the slightest explosion, until it was extinguished by the sinking of the gas-holder bringing the hole below the level of the surrounding water. When an attempt was made to blow up a Glasgow gas house with dynamite only the iron parts were shattered, and the escaping gas burned without explosion. In such cases the ignition of the escaping gas is a safeguard against explosion as it prevents the formation, in large quantities, of explosive mixtures of gas and air.

Even an explosive mixture can be prevented from exploding by the addition of an inert gas. This is of great practical importance because such an inert gas is available in large quantities in the carbon dioxide which constitutes from 8 to 14 per cent of the chimney gas of steam boiler furnaces. Eitner and Trautwein have proved that any mixture of illuminating gas and air can be made inexplosive by the addition of 7½ per cent of carbon dioxide. This fact is utilized for the prevention of explosion due to the mingling of gas and air in the first filling of new gas holders and gas pipes. Furnace gas is blown through the system before the illuminating gas is admitted.

In even the most explosive mixtures explosion can be prevented by cooling below the temperature of ignition. A jet of such a mixture, issuing from a tube a diameter less than 1/12 inch, may be ignited without exploding the mixture inside the container, because of the cooling effect of the walls of the small tube. The construction of Davy's safety lamp for miners is based on this principle. The flame is inclosed in fine wire netting, which is equivalent to a multitude of small tubes. Fire damp (methane), if present in the air of the mine, enters the net and burns therein, without exploding the mixture of gas and air outside.

Some explosive mixtures of gases are usefully employed in heating by gas, in incandescent gas lighting, and in explosion motors. All gas heaters and incandescent burners operate on the principle of the Bunsen burner, which automatically mixes the illuminating or fuel gas, before combustion, with a quantity of air. In gas stoves this addition of air is made in order to produce a non-luminous flame, to prevent the blackening of objects exposed to the flame, and to assure complete and odorless combustion of the gas. These objects are the more perfectly attained the larger the proportion of air that is added to the gas. When illuminating gas at the usual pressure, however, is mixed with more than thrice its volume of air (a quantity insufficient for complete combustion) the velocity of efflux is less than the velocity of propagation of ignition, so that the flame "strikes back." The quantity of air added can be increased by increasing the pressure of the gas. This is especially advantageous in incandescent gas lighting where it is desirable to concentrate the combustion in a small space in order to produce a high temperature, and, consequently, an intense luminosity.

In explosion motors it is advantageous to use as little gas as possible, i. e., to approximate as closely as possible to the lower explosive limit. Richer mixtures (corresponding to the upper limit) cause violent explosions, which are far less completely utilized by the moving parts than the mild explosions and expansion produced by mixtures poor in gas. With some mixtures, especially hydrogen and air, these violent explosions may destroy the motor. The operation of explosion motors with very small quantities of gas or vapor is facilitated by the fact that the explosive range is considerably extended at the high temperatures and pressures that prevail in the interior of the cylinder. These principles have been utilized so fully in recent years that the motors of automobiles have attained a perfection that no one would have ventured to predict twenty years ago. This remarkable development is due to increased knowledge of the behavior of explosive mixtures of gas, and this knowledge has been acquired from practice, not from purely scientific researches. In this field practice is far ahead of pure science.

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* Translated from Victor Rodt's article in *Die Umschau.*

Notes on the Geology of Texas*

In the northwest part of the State, east of the Pecos, the formations lie nearly horizontal. This structure prevails over the entire Plains, extending from the north end of the Panhandle to a line joining San Angelo and Pecos on the south. This area measures 330 miles from north to south and 170 miles from east to west. The deeper lying rocks can hence be known here only from inferences based on their appearance in distant outcrops outside of this area and from such local observations as may be obtained from deep explorations. It is singularly fortunate for our knowledge of the stratigraphy of this part of the continent that a deep boring was made at a point not far from the central part of the area defined. The exploration enables us to know by actual observation what strata underlie. It furnishes a first-hand information of the stratigraphy of this part of the State.

The deepest boring in Texas is now at Spur, in Dickens County, and was made in search of water for the town of Spur, and as a general exploration of the formations of the vicinity. The hole was abandoned and wrecked in November, 1913, at the depth of 4,489 feet. The remarkable feature of the boring was the continuity and the persistency of the rock. The log shows what a tremendous bed of rock was penetrated.

The strata explored by this boring constitute three well marked divisions. The upper 1,250 feet consist of red sands, clays, marls, beds of gypsum, anhydrite, and salt, all in different gradations of purity and intermixture. This is the Permian Red Beds, constituting a part of the Double Mountain formation. The succeeding 2,850 feet consist of dolomite, with strata of anhydrite, sandstone, and shale. These are probably to be correlated with the Delaware formation west of the Pecos and are, no doubt, the equivalent of the Wichita and the Albany, the Clear Fork, and part of the Double Mountain formation. The lowest 389 feet of the section explored consist of limestone and shale, which are believed to correspond to the upper part of the Cisco formation of central Texas.

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* From the *Bulletin* of the University of Texas. "The Deep Boring at Spur," by J. A. Udden, geologist for the Bureau of Economic Geology and Technology.

The uppermost 300 feet of the Red Beds consist of fine silt and clay impregnated with iron oxide, which gives it mostly a deep red color. From 400 to 900 feet below the surface the Red Beds consist for the most part of fine red sand or standstone. The lower 350 feet of the Red Beds consist of a sandy silt mixed with varying amounts of salt, in which the sand and silt particles are imbedded as in a matrix.

There were three beds of pure salt; one ten feet thick, from 570 to 580 feet below the surface; another five feet thick, from 633 to 638 feet; and a third nine feet thick, from 732 to 741 feet. The upper bed consists of white granular salt showing thin red seams about a half millimeter apart, due to the presence of red silt. The lowermost bed is clear, crystalline salt which is transparent, except for imbedded blotches of silt which shows no well-marked stratification.

At Spur, as elsewhere, the most characteristic persistent ingredient in the sediments of the Red Beds consists of calcium sulphate minerals, gypsum, and anhydrite.

From 1,250 feet below the surface down to 4,095 feet the drill was going through what is essentially a formation of dolomites, interrupted by beds of sandstone, shale, and anhydrite, the last of which is to some extent of secondary origin. The thickness of this series is 2,845 feet.

The main accessory sediments in the dolomitic beds are sand, shale, and anhydrite.

In many of the thin sections of dolomite, black, brownish, or yellowish streaks were noted, that evidently were not iron or manganese oxide. On heating parts of some of these samples, and several others, in a closed tube, it was found that nearly all such rock yielded fumes of bituminous materials. In several cases, perceptible films or even minute drops of oil were obtained.

Fragments of limestone first began to appear with the cuttings from 4,100 to 4,105 feet. After its first appearance, the limestone increased in quantity steadily in the returns for the next forty feet. Below 4,150 feet the samples contained but little dolomite, consisting mostly of limestone and shale, down to the bottom of the well.

It is believed that the strata penetrated by the lowermost 394 feet of this boring are to be correlated with the upper part of the Cisco formation in the central part of the State. They consist of limestone and shale. Limestone is the chief rock from 4,100 to 4,400 feet, while the lowermost 89 feet are mostly shale.

Only a few macroscopic fossils were seen. These were in a core taken between the depths of 2,244 to 2,264 feet. All other fossils were minute forms, found either in thin sections of dolomite and limestone or recovered by washing the triturated material in samples of cuttings taken by the drillers.

The principal fossil-bearing horizon is the Cisco, the lowermost 389 feet of the exploration. Fossils occur in the limestone as well as in the shale. Fusulina, Rhombopora, other bryozoa, and crinoid stems were noted most frequently in the limestone. Chitinous and other agglutinate foraminifera, jaws of annelids, and spicules of sponges were most frequent in the shales. A majority of these fossils are known from the Carboniferous in Europe and America, a few are known from the Permian, and some have probably not been reported from any other locality.

A few fossils were noted at scattered intervals in the samples coming from the shaly dolomite beds.

This boring emphasizes the fact, long known, that water is very scarce in the Pennsylvanian and the Permian sediments on the plains of the Southwest, and also that most of the water they contain is too salty for use. The chances are that, if any deep potable water will ever be found in the Red Bed area, it will come from below the Pennsylvanian, and perhaps below the entire Carboniferous, at some depth exceeding 5,000 feet. There can be little doubt that there are at least several hundred, and probably more than a thousand, feet more of Pennsylvanian strata under the bottom of this boring. The existence of such deep water is highly improbable.

What may eventually be the most important economic result of this boring is that it has proved the existence in the dolomite beds of a stratum, or horizon, from which comes a water sufficiently rich in potash to hold out inducement to prospective search for this mineral.

Considering the great value of a workable deposit of potash, it seems worth the while to call attention to another circumstance in connection with these observations. In either direction north or south from Spur the formations lie practically horizontal for at least a hundred miles, and the potash-bearing horizon, whether it be such or not in other places, must be at about the same depth as here, in these directions. It seems to the writer that the general conditions indicated in this boring, the existence of great salt beds and beds of anhydrite, together with the proven potash-bearing stratum, warrants an examination for potash in water from the same horizon in any boring made in this territory.

The rocks of the dolomitic beds, and still more the rocks of the Cisco, must be regarded as sufficiently bituminous to produce large accumulations of oil and gas under favorable structural and lithological conditions. But the fact that the entire column of formations explored in the well below the Red Beds consists of compact sediments that not even yield salt water, shows that the rocks are not in this locality sufficiently porous to have permitted the accumulation of any fluids they may have contained. Everything considered, the prospect for oil or gas in this vicinity must be regarded as decidedly discouraging.

The Work of a Naval Wireless Operator in Times of War*

WAR! Martial law has been proclaimed, the fleets have been mobilized, and the battle maneuvers are now being "practised" in deadly earnest. It is one thing to repel a friendly enemy; it is quite another when the opposing naval forces are, next to our own, the finest in the world.

Let us suppose we are reconnoitering in hostile waters. The cruisers are ordered to spread themselves out in the vanguard of the fleet on lookout duty; they steam along without lights of any description. These great vessels, invisible as the night can make them, are brooding on the troubled waters. Yet they are very alive. Ceaselessly they communicate one with another, for in each vessel, hidden as far as possible from external view, is the soundless and padded wireless room. Here the operator is at work, the electric lamp glowing brilliantly above him; but a messenger enters with an order from the commander; immediately, as the handle of the door is touched and pulled open by the entrant, the lights go out, and pitch darkness prevails, until once again the door is closed behind him, and automatically the lights are switched on—that is part of the secrecy which prevails on a battleship in time of war. The men on lookout duties are stationed in various parts throughout the cruiser; their duty is to keep their eyes open, as there is always a chance that one of the enemy's destroyers may come rushing along at a speed of some 30 knots an hour, shoot a torpedo into the ship, and get away unscathed. At the best of times it takes a cunning gunnery to strike a vessel going at this speed; but in the darkness possibilities of the marauder's escape are increased tenfold, and only the eyes of the crew and watchers can, as far as possible, safeguard mishap. As soon as anything is sighted, it is reported to the battle fleet. This is done by the wireless, and the operator is compelled to work at high pressure, for he has to read every message a cruiser sends, inform his captain, and himself get in touch with the fleet if his officer should desire to send a reply. Then there is the admiral of a fleet to be considered. The operator must keep a good lookout in case some battle order should be transmitted from this important quarter.

All this time, remember, the ship is cruising at imminent risk, not only from the actual attacks of a secret enemy, but from the danger of floating mines and even aerial attack. It requires no little personal courage, therefore, for the operator to remain in that closed wireless cabin, whence, should disaster occur, there is no chance of escape, and all the time he must keep his head, and send and receive messages with as much nonchalance as though he were seated at home in the security of his own little den. But quiet heroism is one of the traditions of wireless service.

Very few people realize the great importance of wireless telegraphy, especially in time of war or strained relations. We will take, for instance, a fleet of battleships at sea while their country is at war with another power. Each ship in that fleet has its wireless installation, adjusted so that they can send and receive signals and messages to other squadrons at sea or in harbor and to stations ashore. One ship of that fleet is always in direct touch with the Admiralty. The chance of interference from an enemy's ship is reduced so as to be almost not worth counting. Each ship in a battle fleet is responsible for some station ashore, or for a cruiser squadron or flotilla of torpedo-boat destroyers.

The importance of having one ship in a fleet always looking out for messages from the Admiralty can be easily seen. All foreign intelligence and the movements of foreign ships go to the capital by telegraph, cablegram, and wireless from different parts of the world, and from thence it is transmitted to the admiral in charge of the fleet, who directs his ships accordingly. The whole safety of a battle fleet depends on wireless telegraphy in time of war. When a number of battleships are steaming along, perhaps looking for the enemy, it would not do for them to run into a superior number of the enemy's battleships.

To guard against this, a great number of cruisers are sent out ahead, and spread a number of miles across. The duty of these ships is to keep a thorough lookout and report to the ship in the battle fleet looking out on their particular tune. This ship, in turn, reports by semaphore or morse-lamp to the admiral of the battle fleet. The cruisers are sometimes assisted by torpedo-boat destroyers. Now, if 30 of these ships are used, it will be readily seen that the area of their vision is enormous, and it would be almost impossible for a fleet to pass unobserved. Immediately any of the ships sight the enemy's squadron, they would report at once by wireless, stating the number of ships sighted, with their speed, latitude, and longitude, etc. The admiral would then give his orders, also by wireless. If the admiral determines to attack, he directs the cruisers to steam at full speed, and take refuge behind the battle fleet.

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* From the Wireless World for September.

Making a Comparison Spectrum

IT is often necessary when making a study of spectra, either terrestrial or celestial, to have a comparison spectra which is capable of furnishing certain of the standard lines. In the *Annual* of the Observatory of Good Hope, J. Lunt suggests that a convenient source for this has been found in the graphite of an ordinary lead pencil, which generally contains sufficient impurities to give lines of iron, titanium, vanadium, chromium, barium, strontium, calcium, and often gallium, scandium, yttrium, silicon, magnesium, manganese, in addition to the carbon.

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Air-Break Switches*

By W. P. Hammond

The question as to the feasibility of the use of air break switches for opening heavily loaded circuits has apparently never been definitely settled, much having been said regarding the danger to equipment attending their use as well as the advantages to be derived therefrom. With the idea of obtaining data from which some definite conclusion might be drawn on this question, there was conducted at Gainesville, Ga., during the months of February and March of this year, a series of experiments extending over three or four weeks, the work being carried out under the direction of Mr. C. E. Bennett, electrical engineer.

The site chosen for the tests is situated about four miles northwest of the city of Gainesville proper, adjacent to the Old Dunlap Power Plant of the Georgia Railway & Power Company and the new high tension lines of this company between Tallulah Falls and Atlanta. The entire output of this station was available for power purposes during the tests, and the high tension lines could be used after twelve o'clock at night to furnish the necessary load. With such ideal location and facilities no expense was spared in making the tests as exhaustive as possible, and the original report contains data on some 275 tests with more than fifty 8-inch by 10-inch photographs and a number of oscillograph records; the instrument for obtaining these records being loaned by the General Electric Company. The several weeks during which the tests were conducted made it possible to note the behavior of the different switches in all kinds of weather. Some of the tests were conducted during a snow storm, some during rain and wind storms, and others in fair weather with practically no wind.

Fig. 1 shows a general view of the switch structure and the manner of connecting up the switches, the incoming leads from the power house being in the extreme right of the picture and the wires connecting with the high tension tower lines immediately above. The

(Continued on page 292.)

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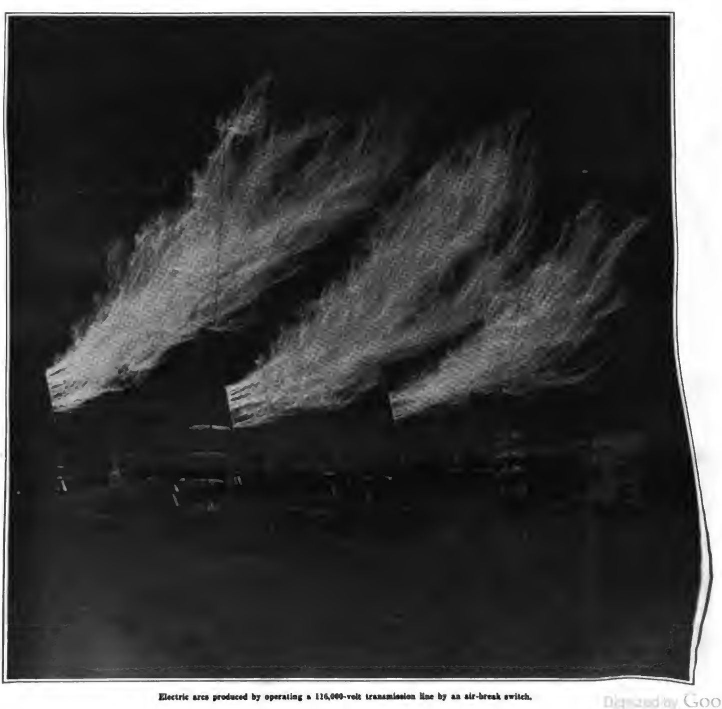
* From the *General Electric Review*.



Electric arcs produced by operating a 116,000-volt transmission line by an air-break switch.

How to Collect and Preserve Insects—I*

Methods and Apparatus Used in an Interesting Pastime

By Frank E. Lutz

"Insects are hexapodous tracheate arthropods," which doesn't help much unless it be translated. On the part of laymen, however, and *this article is intended for laymen*, there is a good deal of haziness as to what are insects and what are not. Arthropods are creatures having jointed appendages but no internal skeleton. The group includes crabs, spiders and centipedes, as well as insects. The tracheate part refers to the structure of the breathing apparatus, but need not concern us here, for "hexapodous" settles the whole matter if one does not object to exceptions. An arthropod with no more than six legs is fairly certain to be an insect. The exceptions to this are minute immature forms not likely to be noticed by the reader. However, a young insect is an insect just as truly as is a full grown one, and while some young insects (flies, for example) have no legs, others (young butterflies, for example) have more than six legs. Perhaps if we call these exceptions maggots and caterpillars, enough will have been said. No mention has been made of wings for two reasons: very many insects never have wings, and no insect has any wings nor even signs of wings when very young. It may be said here that when an insect does have fully developed wings it is full grown. A small winged fly never grows to be a larger fly as many suppose. Most insects have an outwardly quiet stage, called the pupa, between the crawling larval and the flying adult ones, but many other insects remain active, merely gaining more and more fully developed wings at each moult. Compare in this respect the butterflies and the grasshoppers.

WHEN AND WHERE TO FIND INSECTS.

Insect hunting is a sport in which there are no blanks if you know the game. Frequently the most unpromising times and places are the best, for others have been discouraged by the outlook and you get what they have missed. We can never truly say that we know an insect's haunts until we can tell where to look for it every hour of every day in the year. Many insects are great hiders and should be looked for under bark, in rotten wood, under stones, dead leaves, etc.; among the roots of plants, in their stems and flowers—in short, everywhere and at all times.

COLLECTING APPARATUS AND HOW TO USE IT.

The great essentials for insect collecting were given each of us at birth and need only be improved by use—an inquiring mind, eyes, and fingers. Only a very few insects sting to such an extent that collecting with unaided fingers is uncomfortable, and even the swiftest fliers can be caught by hand when they are young or asleep. However, certain tools are handy. They can either be made at home or purchased rather cheaply from dealers.

Mention of insect collecting immediately suggests a net. For the capture of adult butterflies, moths, and other delicate flying creatures this should be of the lightest possible material. Fine Brussels net or bobinet is used for the larger sizes (one half foot in diameter) and silk veiling for the pocket sizes. The depth of this net should be at least twice the diameter of its rim (Fig. 1), so that when an insect is caught a twist will fold the bag against the rim and leave the insect imprisoned in the lower end of the bag. The beginner is apt to choose too long a handle and can then take only long, slow strokes, even if he does not get all mixed up with the vegetation and his fellow collectors. Three feet is long enough for a handle, especially if one handles well the two feet which are covered with shoes.

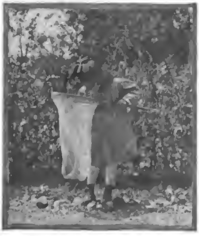


Fig. 1.—A young collector using a net.

The sweeping net should be made of stout white muslin or light duck on a strong rim well fastened to a handle of such a length that the user can just touch the ground with the rim of the net without stooping. The diameter of the net depends somewhat on the strength of the user and its depth may be from one and one half to two times its diameter. It is used to sweep blindly through grass, bunches of flowers, light bushes, etc., in a fairly certain expectation of getting something. Much of the material will be damaged by the rough handling, but it is the quickest way to get large numbers of specimens, and the only way to get certain things quickly. The tendency seems to be to make the handle of the sweep net too short, some on the market being only six inches long. These do not tire the arm so much as nets with longer handles, but you either miss the insects living near the ground or you get a very tired back. One useful trick in sweeping is to have a small cushion (about 2 by 1½ inches) of cotton covered with cheesecloth or muslin and a bottle of chloroform or ether. After sweeping for a few minutes moisten the cushion with the anesthetic, drop it into the net, and quickly twist up the bag so that the fumes are confined. In a short time even the liveliest grasshopper will be asleep and can be picked out and either saved or rejected. If rejected they will all shortly revive and walk, hop or fly away.

The third net of the complete outfit is the water net. The bag should be of some strong material through which the water will run readily. The rim should be strong and may be either circular in outline or flattened at the side opposite the handle. The advantage of the flattening is that the bottom of ponds can be skimmed, but the circular rim does fairly well, as the stirring of the water stirs up even the bottom insects, and they are caught in the return swish of the net. A great deal of mud and weeds will also be caught, but devices to prevent this, such as covering the mouth of the net with a coarse wire screen, does not work well in collecting insects. After clearing the net of mud as much as possible by washing it through the net, dump the rest on the bank, preferably in the sun. Some insects will probably be seen at once, others will appear as the mass dries out. After you think you have found everything, wait a while and look out for very small beetles. Many collectors miss them.

Many or most of the nets that are for sale have folding rims and jointed handles. Opinion differs as to the best. When lightness and ease of transportation is an object it is well to have but one handle and frame with interchangeable bags. The landing net used by fishermen, in which the frame consists of two pieces of flexible steel that lie close together when not in use, is excellent. The two-jointed handle is better than the three-jointed one, as one of the joints of the former is just right except for high flying or deep diving quarry. In these cases add the second.

A sieve is handy for getting the small insects hiding under accumulations of dead leaves, in moss, trash, etc. Two sieves with meshes of different size are handier. A good plan is to have a strong bag about a foot and one half square by two feet deep. About nine inches from the top sew pieces across the corners so that a piece of half-inch mesh wire screen rests on them. Sift through this until there is quite a bit of fine material in the bottom of the bag, and then retire to a comfortable place protected from the wind and spread a small sheet of white muslin or canvas. Now resift, using a mesh about four or five to an inch. The flat-bottomed sieves six or eight inches in diameter which are used for making French fried potatoes and the new wire pie pans are excellent. Sift a very thin layer on to the white cloth and examine carefully the coarse stuff for relatively large things before it is thrown away. Be patient with the small stuff. Insects have a habit of "playing possum" and have plenty of patience themselves. They do not seem to like tobacco smoke. If you do, blow some on the litter. It will hasten matters.

This is a good place to mention collecting forceps, as they are almost necessary in picking up very small [illegible] ll as insects concerning whose ability and [illegible] suspicion. The

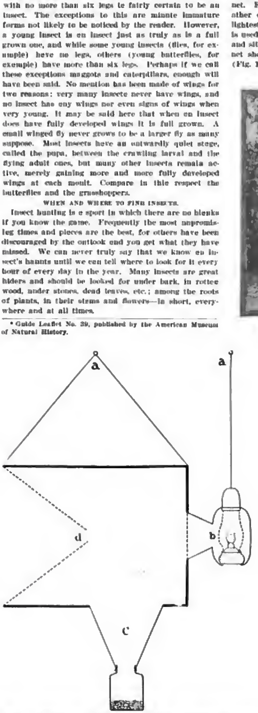


Fig. 2.—Diagrammatic section of a trap for insects which are attracted by light.

a, Supporting strings; b, lamp shut off from the trap by a glass plate or netting; c, canvas bag with cyanide bottle; d, glass plates or netting set at an angle. The space between the inner edges of d should be about one inch wide.

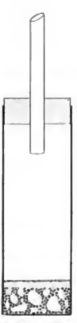


Fig. 3.—A collecting tube fitted with a quill for taking insects out of an umbrella.

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* Guide Leaflet No. 39, published by the American Museum of Natural History.

best forceps for handling very delicate insects do not seem to be on the market. They are made of strips of German silver and have small but rounded points. However, the small steel ones which are on the market do very well. Steel forceps about a foot long are handy for picking caddice cases, etc., out of water, but they are of little use in general work. Dealers also carry forceps having gauze covered frames at the tips. They are meant for holding stinging insects while they are being examined, but they also are of very little use to the general collector.

A strong knife for cutting off galls, stripping bark, splitting infested branches, etc., is essential. A trowel is useful in following insect burrows, or digging for root borers. The entrenching tool used in the army is a handy all-around substitute for trowel, hatchet, and large knife combined.

There are two chief methods of night collecting in general use: sugaring and a light. Another, while not so productive of specimens, is more interesting. It consists in simply prowling around with an acetylene bicycle lamp examining the center of flowers, the underside of leaves, tree trunks, etc., to find out what the nocturnal insects are doing, and also where and how the day flying insects are passing the night.

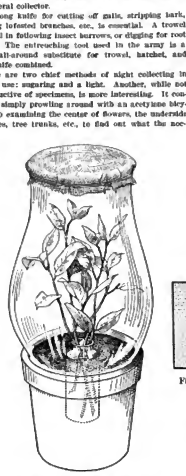


Fig. 4.—A breeding cage.

The flower pot holds earth which contains a growing plant or a bottle with fresh twigs. The lantern globe with a netting cover confines the insects.

There are about as many receipts for making the sugar mixture as there are for "mother's biscuits." Baking molasses usually forms the basis. Some additions are any combination or all of stale beer, rum, asafetida, and brown sugar. The mixture should spread easily but not run badly. It is to be applied before dusk on tree trunks, fence rails, and the like. Starting from some comfortable resting place as a base, lay out a circuitous route, "sugaring" something every few feet, and end at the resting place. After dark, if luck be good, the sugared strips will be full of moths, eagerly sipping the sweets. Several wide-mouthed cyanide killing bottles will be useful, but a net will be practically useless. It is well to have a little ether in each bottle, and do not put a moth in a bottle until its predecessors have stopped fluttering. Only experience will teach how to catch these moths with a bottle. Some fly upward when disturbed and some fly straight out or sideways, but the majority drop a few inches before flying, so when in doubt hold the bottle slightly below the prospective captive.

Light attracts many sorts of insects besides moths. Street and porch lights are fruitful hunting grounds. A lamp by an open window makes the room it is in a splendid trap, or a smaller one can be fixed up and put "in the field." Fig. 2 shows the principle. It is not difficult to make the box collapsible so that it can easily be transported. An ordinary barn lantern set in the center of a white sheet or a "bull's eye" throwing a light against a sheet hung over a fence or between trees does very well. In the latter cases a net will be desirable, but not easy to use. Both light and sugar work best where there is a variety of vegetation, as where woodland passes into swamp or where there is an abundance of second growth.

Many other sorts of traps have been devised. Olive bottles and fruit jars buried up to the neck in the ground and baited with molasses, meat, etc., are simple and effective. The insects caught in this way may be washed off in alcohol and will be nearly as good as new. Boards daubed on the under side with molasses or covering meat are not bad. Girdled branches and cut limbs hung up attract wood boring insects, which can then be collected by beating them into an upturned umbrella by sharply rapping the limbs with a stout stick. In fact, an umbrella is a very useful piece of apparatus. Branches, both living and dead, are full of insects. The inverted umbrella catches what are knocked off, but does not hold them for long. The collector must act quickly. Some collectors put a quill in the cork of a collecting tube as shown in Fig. 3. If the outer end of the quill be put over the insect it will crawl up through the quill and into the bottle, from which exit is difficult. If the umbrella be white, or at least lined with white, the insects can be more easily seen, but so can the collector—not by the insects particularly, but by inquisitive humans—and the non-committal black does very well.

Beating will knock down many larvæ. Directions for preserving them are given later on. Some, at least, should be reared, and here ingenuity is of more value than volumes of instructions. The beginner will doubtless be inclined to give his charges more light and air than is necessary. Pasteboard shoe boxes are excellent for large caterpillars. Tin boxes keep the food longer and are easily cleaned, but must be watched carefully or the food will mould. If the food plant can be potted, a good contrivance is to slip a lantern globe over it, sinking the bottom far enough in the ground to prevent the escape of larvæ in that direction and covering the top with cheesecloth. Even if the plant cannot be grown, twigs can be kept fresh for some time by keeping their cut ends in a small bottle of water sunk in the ground and used inside a lantern globe. (See Fig. 4.) The twigs will be held in place and larvæ prevented from drowning if cotton be loosely stuffed in the neck of the bottle around the twigs. It is well to throw a thin layer of dirt over the cotton so that fallen larvæ can easily get back to their food. A useful device for certain larvæ (not leaf eaters) is shown in Fig. 5. It is made of plaster of paris. The water at one end keeps the block moist. It is useful chiefly for ground-inhabiting larvæ or for galls. However, for the latter fruit jars with moist sand in the bottom or a moist sponge does just as well or better. Do not forget the larvæ living in hollow stems, dead wood, and under bark.

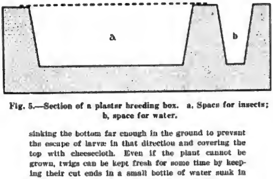


Fig. 5.—Section of a plaster breeding box. a, Space for insects; b, space for water.

KILLING.

Up to this point but little mention has been made of killing insects, and that was not really necessary. Insects can be studied alive with great pleasure and profit. However, there are so many kinds (about 15,000 in the vicinity of New York city, for example), and the differences between species are often so minute that it is well to kill and preserve samples at least.

The best all-around killing agent for adult insects is cyanide of potassium. It should be broken into pieces varying in size from the size of a small pea to that of a hickory nut, according to the size of the bottle to be used. Olive bottles make good medium-sized bottles, while fruit jars are better for large sized moths and butterflies. Tubes even as small as ¼ inch in diameter by about 2 inches long are not too small for some things. Avoid bottles with strongly constricted necks. Avoid also bottles made of thin glass. There are many ways of keeping the cyanide in position and the bottle in good condition. The most general way is to pour a thin layer of plaster of paris over a layer (from ¼ to ¾ inch deep) of cyanide. However, since such a bottle will quickly get too moist from the specimens and the decomposition of the cyanide, some further device is almost always used. The pieces of cyanide may be wrapped in soft absorbent paper or imbedded in dry sawdust before the plaster is poured on. Another way is to imbed it in dry plaster before pouring on the wet. A piece of blotting paper should be fitted tightly over the plaster after it has "set." See Fig. 6. Some do not use plaster, but imbed the cyanide in cotton and cover this with a piece of blotting paper or a thin porous cork. A dangerous but otherwise fairly satisfactory method is to imbed a piece of cyanide on the inside surface of the cork and have none in the bottle itself. This bottle will be dry but not strong, and as the cork will in time become saturated with poison, it will be very dangerous. It is always well to have a few narrow strips of loose absorbent paper in the bottle. They prevent injury to the insects by shaking and help keep the bottle dry, as they can be frequently changed. As ordinarily made, a bottle should be allowed to ripen for several days before using. If wanted at once, put a few drops of vinegar or a pinch of boracic acid powder with the cyanide. Collectors of delicate moths and butterflies frequently put a few drops of ether or chloroform in their cyanide bottles before starting out. This is to quiet insects at once, for the cyanide sometimes kills slowly. Experience will teach the collector that some insects die very slowly and revive after apparent death. On the other hand, ether and chloroform make insects brittle, and too long an exposure to cyanide fumes changes the color of some insects.

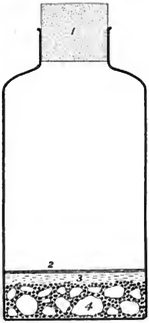


Fig. 6.—Diagram of a cyanide killing bottle.

1, cork; 2, blotting paper; 3, plaster of paris; 4, pieces of cyanide in sawdust.

Practically all beetles and dragon flies, together with dull colored, hairless insects of other orders, can be killed in alcohol and kept there indefinitely. Fifty per cent is strong enough for killing and 70 per cent for preserving. Higher grades make them brittle. No fly, bee, butterfly, moth, or any green insect other than previously mentioned should be put into alcohol. In an emergency, kerosene, gasoline, or benzine put on the thorax will kill and give satisfactory specimens. The thorax is the part of the body which bears the wings and legs. Insects breathe through holes in it and in the abdomen; not through the head. Pounded laurel leaves and peach pits make a weak killing agent, and butterflies and moths may be killed by carefully but firmly pinching the thorax between the thumb and finger, one on each side. In fact many collectors of these insects pinch their captures before taking them out of the net. This stops their injuring themselves by thrashing about.

(*To be concluded.*)

Anthropological Survey of Canada

THE Geological Survey of Canada has been conducting a number of interesting operations during the past season. In Nova Scotia, Harlan I. Smith has been making investigations of the shell heaps of Merigomish and important results are anticipated, as it is known that the country around the Gulf of St. Lawrence was formerly inhabited by no less than four totally different peoples. In southwestern Manitoba, W. B. Nickerson is continuing the explorations of the mounds, earthworks, and village sites; and W. J. Wintemberg is examining a section of the country between Prescott and Peterborough for a site of culture different from that of the Roebuck site where he excavated in 1912.

Air-Break Switches

(Continued from first page.)

switches tested consisted of one LG-9 110,000-volt General Electric switch, and three or four 44,000-volt air-break switches of different types. The tests, however, were not regarded as competitive between the different makes of switches, and were conducted mainly for the purpose of determining how different weather conditions affected the operation of air-break switches, and the effect on the lines and other equipment resulting from their use.

44,000-VOLT SWITCH TESTS.

Fig. 3 shows a one-line diagram of connections as made for the 44,000-volt switch tests. The power was token from 550-kilowatt, two-phase, 60-cycle generators in the Dunlap station at 440 volts. This voltage was stepped up to three-phase 50,000 volts through two banks of Scott connected transformers, each bank consisting of two 550-kilowatt units. There was also available for use in connection with the oscillograph, a spare 50,000/440-volt, 550-kilowatt transformer which made it possible to take the voltage curve of the oscillograph record from the high tension side of the power transformers. There was placed in the circuit on the power side of the switch a 50,000-volt 10 to 1 current transformer which was connected to one of the other oscillograph vibrators for recording the current wave. The third vibrator of the instrument was connected to the load side of the switch through suitable potential transformers, but could only be used when that part of the line to which these transformers were connected furnished part of the artificial loading, which was not the case in all of the tests.

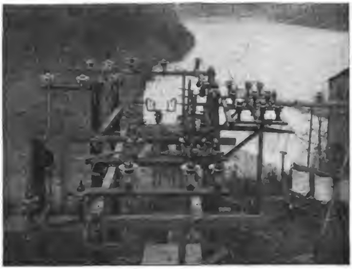


Fig. 1.—General view of switch structure.

As previously stated, the artificial load consisted of the charging current on the high tension lines of the Georgia Railway & Power Company between Tallulah Falls and Atlanta, the tests being conducted after midnight. The lines are constructed of 4/0 stranded copper spaced 9 feet vertically and insulated for 110,000 volts. The distance from Tallulah to Atlanta is approximately 90 miles, the Dunlap station at Gainesville being about midway between. There is a tie switch between the two lines, known as the north and the south lines, at this station with sectionalizing switches on both lines on both sides of the station, so that the lines can be easily separated into four different sections right on the grounds where the tests were conducted. Each of these sections of about 45 miles in length furnished approximately 7 amperes charging current at 50,000 volts, making the maximum load with all four sections cut in, 28 amperes, or about 2400-kv-a. of leading power-factor. These four sections, together representing a total of 180 miles, imposed rather a severe load on a 44,000-volt air-break switch. It is not often that power is transmitted so great a distance at this voltage, and an air-break switch of this rating would probably never be called upon to open a circuit of this length.

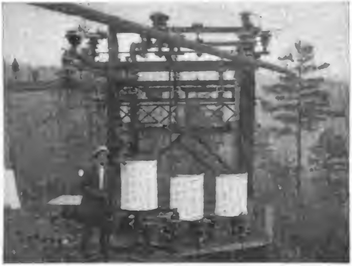


Fig. 2.—Water rheostat.

A water rheostat was rigged up in the field for furnishing a true energy load, and although rather crude in construction, served the purpose admirably, drawing as high as 50 amperes in some of the tests. (See Fig. 2.)

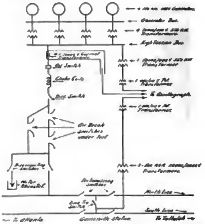


Fig. 3.—One-line wiring diagram for 44,000-volt switch tests.

In order to get a better check on the voltage surge set up on the load side when opening the circuit with an air-break switch, a needle point spark gap was connected between two of the phases, set accurately for different voltages, and the maximum sparking distance noted for each switch under the same load conditions. The same experiment was tried with an oil-break switch in the circuit, and the maximum sparking distance recorded when the circuit was opened with this switch was greater than with the air-break switch.

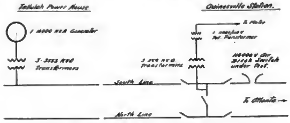


Fig. 4.—One-line wiring diagram for 110,000-volt switch tests.

110,000-VOLT TESTS.

In Fig. 4 is shown the wiring diagram for connections as made for the 110,000-volt switch tests. The power was taken from one 10,000-kv-a. generator at the Tallulah Falls power house and stepped up through one bank of three 3333-kv-a. transformers delta-Y connected. The switch was connected in the south line at the Gainesville station, as shown in the diagram, and opened under line voltage varying from 65,000 to 120,000, the charging current varying from about 18 to 29 amperes, these readings being taken at the power house. These figures cor-

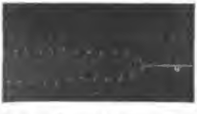


Fig. 6.—Oscillogram made at the time of interrupting a 3,000 kv-a. load at 50,000 volts by a 44,000-volt air-break switch.

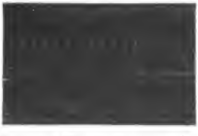


Fig. 8.—An Oscillogram made at the time of interrupting a 1,720 kv-a. charging current by an oil switch.

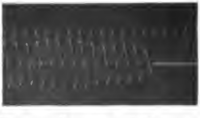
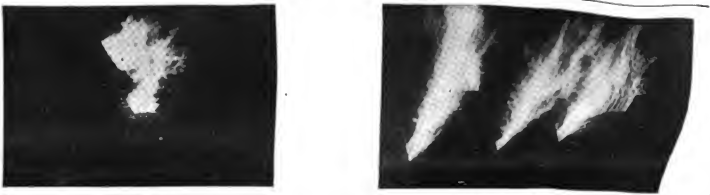
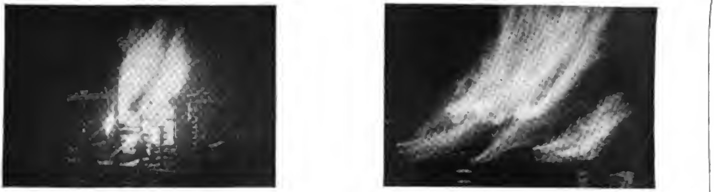


Fig. 7.—An oscillogram made at the time of interrupting an energy load of 2,500 kv-a. with an air-break switch.



50,000 volts, 650 kv-a.

50,000 volts, 1,700 kv-a.



50,000 volts, 2,400 kv-a.

112,000 volts, 5,230 kv-a. c.c. load.

Fig. 5.—Photographs of arcs rising from air-break switches under the loads indicated in the oscillograms illustrated.

respond to a kv-a. load of from 2000 to 6000, only half of which was actually interrupted by the switch on account of its location at the mid point of the line.

OSCILLOGRAPH RECORDS.

In Fig. 6 is shown one of the oscillograph records obtained while interrupting a load of 3,000 kv-a. at 50,000 volts with one of the 44,000-volt switches, the time required to break the arc being three seconds. The upper curve is the voltage curve on the power side of the switch and the lower one the current on the same side. The load was a true energy load obtained by means of the water rheostat.

Fig. 7 shows a record obtained while breaking a true energy load of 2,500 kv-a. with a different make of air-break switch, the time necessary in this case being the same as in the previous one. The upper curve is again the voltage curve on the power side of the switch and the lower one the current.

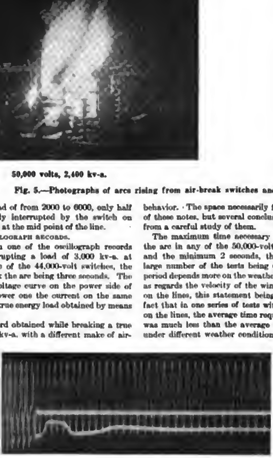


Fig. 9.—An oscillogram made at the time of interrupting a 1,250 kv-a. charging current by an air-break switch.

Fig. 8 shows, for comparison with the foregoing records, a record obtained while interrupting a charging current load of 1,720 kv-a. with an oil switch, the voltage and current curves occupying the same relative position as in the records already referred to.

Figs. 9 and 10 are records obtained when opening charging current loads of about 1,250 kv-a. with two different makes of air-break switches, the upper curve being the voltage, the middle one the current on the power side of the switch, and the bottom one the voltage on the load side.

The remaining cuts shown herewith are actual photographs of the arcs which resulted when opening the circuits under the loads indicated, an explanation of which is hardly necessary.

GENERAL CONCLUSIONS.

Complete records were kept of the load and weather conditions of each test, and the actual time in seconds required to break the arc, with a short description of its behavior. The space necessarily forbids the publication of these notes, but several conclusions have been drawn from a careful study of them.

The maximum time necessary in which to interrupt the arc in any of the 50,000-volt tests was 25 seconds and the minimum 2 seconds, the average time for a large number of the tests being 6 seconds. This time period depends more on the weather conditions, especially as regards the velocity of the wind, than the kv-a. load on the lines, this statement being substantiated by the fact that in one series of tests with a certain kv-a. load on the lines, the average time required to break the arcs was much less than the average time in another series under different weather conditions when the kv-a. load was smaller. The average time necessary to interrupt the arcs in the 110,000-volt tests was 7 seconds, the maximum being 16 and the minimum 3.

This means that the air-break switch requires anywhere from 120 to 1,500 cycles in which to interrupt a circuit, while the oil switch may accomplish this result in half a cycle. This time element in the case of the air-break switch produces an effect on the lines similar to a series of light hammer blows, and these blows, although probably not so violent as the one caused by an oil switch, must nevertheless have a damaging effect on the insulation.

The rating given air-break switches by the manufacturers is more or less arbitrary. The spacing adopted, especially as regards the distance between phases, is however not sufficient, as the lines are easily short circuited by the arcs lapping between the phases. The distance between phases for a 44,000-volt switch should be 6 or 7 feet, and for a 110,000-volt switch certainly not less than 10 feet. The switches tested were spaced 4, 5, 8 and 10 feet, and in many of the tests the arcs lapped between the phases, as shown in some of the photographs. Great care must be exercised in wiring up the switches to prevent the arcs of one phase from lapping the leads to some other phase. In other cases, the arcs are blown directly downward, and this means that the switch must be properly spaced from the frame or steel structure on which it is mounted to prevent the arcs grounding the lines. The large amount of space necessary for the installation of air-break switches because of the foregoing precautions which must be taken is a serious drawback to their use.

It may be safe to advance the opinion that the proper design of an air-break switch involves a mechanical movement which will assist in drawing the arcs up the horns, as the heat of the high voltage arcs alone is sufficient to accomplish this only in a very still atmosphere. With the slightest breeze blowing the arcs sometimes hold to one point of the horns for many seconds before exhibiting any tendency to rise. In one of the switches tested, advantage was taken of this point in the mechanical design, and this switch broke the arcs much more readily than the others.

It was found that a true energy current is more easily interrupted than a charging current of the same kv-a. value under the same weather conditions, and that under

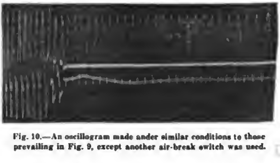


Fig. 10.—An oscillogram made under similar conditions to those prevailing in Fig. 9, except another air-break switch was used.

light loads, high winds materially aid in breaking the arcs, sweeping them from the horns soon after their formation. With heavier loads, or lower winds, however, the arcs lap between phases with the spacing used in these tests before they are blown from the horns.

The oscillograph records obtained during these tests do not indicate that there is any high frequency set up on the lines by air-break switches which is especially dangerous to the equipment. It is possible, however, that the oscillograph does not show such oscillations, and these records cannot be relied upon to establish this fact conclusively. The spark gap test previously referred to in this article would indicate that the surges in the voltage set up by the air-break switch are not so violent as those set up by an oil switch, although this statement is not in line with the current opinion.

The general conclusion drawn from these tests is that the air-break switch will doubtless replace the oil switch for many uses, such as sectionalizing short lines, cutting in and out equipment only occasionally used, for emergency use, etc.; but where frequent switching is necessary and the time element in breaking the circuit of consequence, the air-break switch in its present stage of development would hardly prove satisfactory.

The Origin of the Word "Engineer"*

Its Etymology and Applications Considered

By Hunter McDonald

I have been tempted to delve somewhat deeper into the origin and present meaning of the word "engineer" than my predecessors in office have done. Realizing my own lack of fitness for the task, as far as the origin is concerned, I called in a specialist on etymology, Dr. Bert E. Young, professor of Romance Languages of Vanderbilt University, and lately honored by the French government with the decoration of Officer of Public Instruction for distinguished services in the promotion of French literature.

I quote his statement in full:

"I take pleasure in furnishing the best information I have as to the origin of the word 'engineer':

"'Engineer,' formerly 'enginer,' or sometimes 'ingenier,' Middle English 'engyneour,' from the Old French 'engignier' or 'engigneour,' or shorter 'engineur.' This from Middle Latin 'ingeniarius,' one who makes or uses an engine, especially a war engine. 'Engine' is from Latin 'ingenium,' an invention, an engine.

"The French word 'ingenieur,' a semi-learned form, seems to come down by a slightly different road, being from the hypothetical Middle Latin word 'ingeniator' from 'ingeniare' from 'ingenium,' an engine. Or else the Modern French 'ingenieur' is an alteration of the better form 'engigneur,' mentioned in first paragraph.

"'Genie,' from Lat. 'genius,' orig. a spirit, extended as a term of war to the sense of 'art' of attacking or defending fortified places, etc., and then to the arm of the service devoted to military or naval engineering.

"'Ingenuity' from French 'ingenuite' from Lat. 'ingenuita' (t) s from 'ingenuus,' native born of free parents, frank, generous. 'Ingenious' from Lat. 'ingeniosus,' gifted with genius or natural capacity. Lat. 'ingenium' from Old Latin 'genere.'

"Apparently all go back to the ubiquitous root, 'gen,' to bear, to produce, to give birth to.

"Misc. remarks:

"Considering the derivation of ingenuity, there must have been confusion of Lat. 'ingenuus' and Lat. 'ingeniosus.' These should be almost opposite in meaning. I suppose an 'engineer' ought to be both 'ingenious' and 'ingenuous,' artful and artless, sophisticated and unsophisticated, bond and free. According to the above, I should say that the man who pronounces 'injine' is only atavistic.

"Ex.—'In hys court was a false traytoure, that was a grete Yngynore (plotter). (Halliwell, 1420).'

"Ex.—'The most prime Engineers of Oaths that ever the world knew. (Butler, 1680).'

"Ex.—'For 'tis the sport to have the engineer hoist with his own petar. (Shak., 1602, Ham, III, 4, 206).'

"Ex.—'The Ingener of this practice—was a Portugal. (Carew, 1620).'"

From the Oxford Dictionary, which no doubt gives the prevailing English view, I have extracted the following definitions and examples of the use of the word "Engineer."

"One who contrives, designs, or invents. Ex. 1611, Rich. Honest age, 1844 (36) 'Yet you cannot deny them to be the devil's engineers.'

"1655, R. Gibbs in Spurgeon 'That great engineer Satan.'

"A constructor of military engines (Obsolete). One who designs and constructs military works for attack or defense. 1325 Coer De Leon 1387—'a tour ful strong, that quaynte ly engyneours made.'

"A soldier belonging to the division of the army called engineers, composed of men trained in engineering work. Ex., Porter's History, Royal Engineers. 'This day (May 26th, 1716) may thereafter be taken as the one on which the engineer branch blossomed into a distinct corps.'

"One whose profession is the designing and constructing of works of public utility, such as bridges, roads, canals, railways, harbors, drainage works, gas and water works. From the eighteenth century, also civil engineers (from the military).

"Ex. 1792 Smeaton Reports (1797) I pref. 7. 'The first meeting of this new constitution, the Society of Civil Engineers, was held on April 15th, 1793.' Ex. Eddyston L. introduction—'My profession of a civil engineer.'

"A contriver or maker of engines (specially mechanical engineer.)

"One who has charge of a steam engine. In England only with reference to marine engines. In the United States often applied to the driver of a locomotive. Ex. 1860, Bartlett's Dictionary. American, engineering, 'the engine-driver on our railroads is thus grandiloquently designated.'

"Engineman, one who works or helps to work a fire engine. One who attends to a stationary engine. The driver of a locomotive."

From other English authorities:

March's Thesaurus Dictionary. "One versed in any branch of engineering. To manage skillfully. The science and art of building, making, and using engines and machines."

Hallowell's archaic and provincial words. "Engin, wit, contrivance (Lat.) Inginous, inventive (Johnson)."

From Joseph Wright's Dialect Dictionary. "In 1649 Gray wrote 'Master Beaumont a gentleman of great ingenuity and rare parts adventured into our mines, who brought with him many rare engins. The memory of these 'rare engines' survives in the name of the seam which he appears to have discovered, still called the engin seam." It will be noted that Beaumont was practising civil engineering at quite an early date.

From the Century Dictionary, presenting the American view, the following:

"A person skilled in the principles and practice of any department of engineering. Engineers are classified according to the particular business pursued by them, as 'military,' 'naval' or 'marine,' 'civil,' 'mining,' 'mechanical,' and 'electrical' engineers.

"To work upon; ply; try some scheme or plan upon.

"Ex.—'Unless we engineered him with question after question, we could get nothing out of him.'—Cowper.

"To guide or manage by ingenuity or tact; conduct through or over obstacles by contrivance or effort; as to 'engineer' a bill through Congress."

Through the kindness of our secretary, Mr. Hunt, I have been able to secure the following translations from the Dictionnaire de la Langue Française:

"One who plans, lays out and directs field work and fortifications, for attacking, defending, or fortifying places.

"Ex.—'Then he (Peter the Great) has had even a school of engineers in a country where no one (before him) knew the elements of geometry, Volt. Charles XII 1.'

"One who directs [private] works or public works, such as the construction and maintenance of roads and bridges, working of mines, etc. Engineer of bridges and roads. Mining engineer, naval engineer, or marine engineer, railroad engineer.

"Civil engineer, name given to engineers who are not trained in technical schools or who work for private industry.

"Naval architect or engineer, one who applies himself to the art of naval construction.

"Topographical engineer, one who draws maps. Hydrographical engineer, see hydrography.

"Engineer for mathematical instruments, one who makes mathematical instruments."

Also, from Cotgrave's Dictionary of the French and English tongue:

"Enginier.—An engineer; a maker of engins.

"Enginer.—Engigner

"Engigner.—A deceiver, beguiler, cousener; also an enchanter.

"Engin.—An engine, toole, instrument; also understanding, pollcie, reach of wit; also suttletie, fraud, craft, villany, deceit.

"Ingenieur.—An enginer, engine-maker; fortifier."

Mr. Hunt also furnished me the following translation from Grimm's Deutsches Wörterbuch:

"Engineer, n.—This word of the present day, for military architect, surveyor, introduced from a foreign language in the seventeenth century, represented an artful calculating person in general. Ex.—'He who wishes to bring Germans into an understanding must be a very good and wise engineer (schemer, calculator).' Weidner's, Zinkgref, 3, 158."

No trace of the use of the word "engineer," or of any of the words from which it is derived in describing the building of any of the ancient structures has been found. That engineers of great skill existed is evidenced by monumental and written records, but they were designated otherwise, as, for example: Frontinus, in his water supply of the City of Rome, as translated by Clemens Herschel, M.Am.Soc.C.E., mentions "moduli" (levelers), "scientia" (builders), "agrimensores" and "geometricii" (land surveyors), "architectos" (architects), and "Curator Aquarum" (Commissioner of Waterworks), but none of the Latin words from which the word "engineer" is derived are used in connection with the process of building or maintaining. The conclusion is inevitable that the name at least is comparatively modern, and that the attempt to class the calling among the learned professions is still more so.

John Smeaton was the first engineer to style himself civil engineer (probably in 1782).[1]

In the annual address of Mr. Charles Hawksley, president of the Institution of Civil Engineers, 1901, an extensive quotation is made from the report of the council for the session 1885-86. A portion only is repeated here:

"'The honor of having originated the Institution is often assigned to Smeaton, or to Telford, but the idea is erroneous in both cases. Smeaton died many years before it was thought of, and Telford only joined it after its establishment.'

"A society of engineers, still existing, was founded by Smeaton in 1771; it includes many of the most eminent members of the profession, but it is rather of the nature of a social club than of a scientific association, and has no connection with this institution."

To those who are interested in the beginnings of engineering, I would recommend an examination of the two papers above referred to and the following: Annual addresses of Past-Presidents William E. Worthen, 1877 ("Transactions," Vol. XVII), and William P. Shinn, 1890 ("Transactions," Vol. XXII), also of Charles B. Vignoles, F.R.S., past-president, Institution of Civil Engineers, 1870 ("Minutes of Proceedings," Vol. XXIX).

On page 604, of *Engineering News*, May 26th, 1910, is an entertaining paper, entitled the "Origin and History of the Profession of Civil Engineering." A footnote describing it reads as follows:

"An appendix to the presidential address of James C. Inglis, president of the Institution of Civil Engineers of Great Britain. Abridged from the account contained in the life of Sir William Fairbairn by the late Dr. William Pole, F.R.S., secretary of the Institution."

A portion of the beginning is quoted:

"The root of both the words, engineer and engine, is found in the Sanscrit 'jan,' to be born, from which came the Greek form γεν, and the Latin 'gen,' the latter being embodied in the old verb 'genere,' with its compound "ingenere" (changed into ingignere), to implant by birth, and in their later substantive 'ingenium,' an innate or natural quality.

"The old Latin verbs, 'genere' and 'ingenere,' gave rise to the French form, also a verb, 's'ingenier.' This is of great antiquity, and from its comprehensive and useful meaning it has continued in use down to the present time, being found continually in modern French writings. The import of it has nothing whatever to do with engines or machines, but is purely psychological. It is given in Littre's great French dictionary:

"'Chercher dans son genie, dans son esprit, quelque moyen pour reussir.'

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* From the Presidential Address at the recent Annual Convention of the American Society of Civil Engineers.

[1] See discussion by Clemens Herschel, M.Am.Soc.C.E., of Paper No. 472, entitled "Beginnings of Engineering," by the late J. E. Watkins, Assoc.Am.Soc.C.E., "Transactions" Am.Soc.C.E., vol. xxiv, p. 382.

"Now, all authorities, including our own great Lexicographer, agree that this word is the true origin of the word 'engineer,' and thus we arrive at the interesting and certainly little-known fact that an engineer is, according to the strict derivation of the term, not necessarily a person who has to do with engines, but anyone who seeks in his mind, who sets his mental power in action, in order to discover or devise some means of succeeding in a difficult task he may have to perform."

There are sufficient divergences of authority and definitions in the above quotations to give room for any amount of argument.

These matters are mentioned primarily as leading up to a consideration of the condition in which the profession in this country now finds itself. There is ample evidence that the word "engineer" is now applied alike to the designers of engineering works and to the operators of engines. It is also evident that civil engineering is now considered by many to be a branch of engineering. In the language of the late Grover Cleveland, "It is a condition, and not a theory, which confronts us." We could not, if we desired, compel the public to call locomotive engineers "enginemen" or "enginedrivers," nor stationary engineers "power superintendents," notwithstanding the fact that such they are. President Worthen, in the address above referred to, says: "I would drop the term 'civil' as embracing too large a profession, and adopt prefixes, as military, hydraulic, railway, mechanical, steam, electric, and other divisions, when these are adopted as specialties." His idea seems to have been merely to divide civil engineers into different classes. He does not mention civil engineers as one of the classes.

Until recently I have also been inclined to the view that we should drop the word "civil" from the name of our society; but a closer study of the matter confirms me in the opinion that we should retain it. I think there can be no question but that civil engineering embraces all engineering except that connected with the actual conduct of war. The fact that the military engineer "in piping times of peace" performs the work of the civil engineer constitutes no distinction.

Two Phenomena That Are Still Mysteries*

Spontaneous Ionization and Penetrating Radiation.

Air is generally believed to be an insulator, electrically speaking, and it has been taught that dry air is a perfect insulator. In reality, however, it loses this property under certain conditions like the ultra-violet ray, the Roentgen ray and the influence of radio-active bodies. Changes are here evident that affect charged corpuscles—some negative and some positive—to which the name ions has been given. When these are attracted by conductors of opposite sign placed in their vicinity the ions abandon their charges to the conductors on contact.

Thus the air and gases in general become conductors when they are ionized. Further, the ionization of a gaseous mass abandoned to itself generally disappears quite rapidly when the ionizing cause, ultra-violet, radium rays, X-rays, etc., ceases to act. The ions of opposite charge combine to form a neutral particle, or coming into contact with the walls of the receiver containing the gas give up their charges. Such conditions are those of prediction and in a general way have been verified by experiment.

But when it comes to precise measurements it has been recognized that gas or air, hermetically sealed in a closed receptacle, preserves its conductivity, feeble but very appreciable, and this, far from disappearing, slowly increases up to a certain limit-value, reached in several days. After this it remains constant. This fact, discovered at about the same time (1890) by Geitel and Wilson, has puzzled physicists and to such a degree that, not finding any known cause, it has been quoted as the manifestation of a new property of matter, spontaneous ionization, whereby the ions take birth spontaneously in the midst of a gaseous mass, and this indefinitely.

But in reality there need be but little difficulty in finding out the probable causes of ionization if the precautions taken have been most minute. First of all, bodies of gas are likely to have in them traces of emanations from radio-active substances (radium, thorium, actinium, etc.) and in introducing gas into a receiver these emanations go with it and are causes for the production of ions. Also the walls of vessels that have been exposed to the free air, before experimenting, are probably covered with a deposit of radio-active substances, which, in being dissipated, make the gas a conductor. The walls of the container may further exercise an action of their own, which depends on their nature and on the impurities they contain. Such action (of impurities) would be at the maximum for lead and tin, at the minimum for aluminium and zinc and feeble for iron. Thus the ionization of gas within a receptacle may be influenced by the content of the exterior medium, by Roentgen rays and similar ones, and by the gamma rays of radium, which can traverse the walls and produce their effect within them. These rays are very penetrating, and there are few obstacles that will really stop them. They may, however, be excluded by screens of lead, and if one will experiment by inclosing the receptacle in screens of increasing thickness there will be observable progressive diminution of ionization down to a value which does not diminish even with greater thickness of the screen.

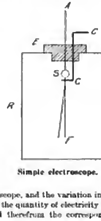
It is necessary, in getting at the truth, to eliminate successively all such sources of ionization, and to learn whether in their absence there will still exist traces of this kind of activity.

To cleanse internal surfaces properly sandpapering is efficient, together with washing with hydrochloric acid, water and ammonia and alcohol, and the radio-active deposits will have disappeared. A slow filtration of the air, as admitted through absorbent cotton or other porous material, will keep out emanations. As for the receptacles, while it is quite probable that lead will contain radio-active impurities, there seem to be no reasons for questioning most other metals, notably aluminium and zinc. Of the latter many samples tested have shown reasonably uniform quality measured by the ionization that goes on within them. With the quality of the material of the receptacle assured, radiations from the outside may be stopped by adequate screens of metal opaque to the radiations.

When all this is done, and all precautions taken, the fact remains that there still exists a residual, permanent ionization of a value of about half that which would be observed with the same receptacle cleansed and filled with inactive air and left unprotected by screens.

This leads us to the consideration of the method of measuring. The conductivity in closed receptacles is always very weak in comparison with the conductivity of free air, which is itself small when referred to the values obtained for the ionization of gas in the laboratories. It is therefore necessary to have recourse to a very sensitive electroscope of small capacity, so disposed as to avoid losses through the conductivity of supports or the effects of exterior electrostatic action. It is necessary further to work with a voltage sufficient to maintain the current to saturation throughout the measures.

The first observers measured the conductivity of the gas by the loss of charge per unit of time, indicated by a very sensitive electroscope placed within the receptacle, which was itself grounded. From the known capacity of the electroscope, and the variation in potential during a given time, the quantity of electricity dissipated can be deduced, and therefrom the corresponding number of ions.



Simple electroscope.

The figure shows one of these arrangements, an electroscope with gold or aluminium leaf which is repelled from the vertical plate, *F*. The device is held in place within the receptacle by the wire *A*, which passes through a disk of ebonite, *E*, and is insulated by terminating in a button of sulphur, *S*. The electroscope is charged by means of the bent wire, *C*, which may be turned in the ebonite cork so as to make or break contact with *F*.

Apparatus of greater precision may be made, but it is not the purpose of this article to discuss it. The suggestion here is sufficient to present the principle.

Passing to the consideration of the principal results of which these delicate measures permit the establishment, estimates have been made of the number of ions originating per second in a cubic centimeter of gas. It should be remembered that the charge of each ion is supposedly equal to an elementary charge of electricity, 4.5×10^{-10} electrostatic unit C. G. S.

A physicist, H. L. Cook, working with a composite receptacle of about one liter capacity, the walls of which had been carefully cleansed, observed 11.3 ions per cubic centimeter per second. But by surrounding the receptacle with a lead envelope sufficiently thick the number of ions was reduced to 7.5. The excess, 3.8, is the number intercepted by the lead screen in the second experiment. Another observer, McLennan, experimented in the laboratory of the University of Toronto, near Lake Ontario. The measures made above the lake have always given smaller values, the water, like the lead, seeming to act as a screen to the mysterious rays which have been called penetrating radiation. Under the most favorable conditions, with a zinc receiver well cleansed, and with the elimination of the effect of the soil by the waters of the lake, the product of ions in the receptacle may be reduced to 4.5.

More recently still two scientists, Simpson and Wright, during a voyage from England to New Zealand, made a series of interesting observations. In the open ocean, distant from the shores, the production of ions was quite uniform, varying from 6 to 7, with the mean number 6.3. This was always smaller than the count upon land. To emphasize the difference, the counts obtained in Africa may be quoted. During a stop at Cape Colony a trip was made into the interior and at Matjesfontein a number of measurements gave a value of 12.3 or 6 more ions than that on the sea. The number 6 represents the penetration effect of the soil or land radiation, if one assumes that of the vessel and the sea to be zero. These observations show that ionization was always stronger near the coasts where it was about 9 ions while it regained its minimum of 6 only after the ship had been for a considerable time at sea.

From all these observations and investigations there are to be reached two general conclusions; first, that exteriors send rays capable of traversing the walls of receptacles, and such radiation can be eliminated only by using precautions which reduce the product of ions to about 6 per cubic centimeter. These rays constitute what may be termed penetrating radiation. In addition, even when the known causes of ionization have all been eliminated the ionization of gas in a closed receptacle does not cease, but remains at about 4 ions. The residual ionization may be termed spontaneous.

Whence comes the penetrating radiation? Examining the radio-active substances which exist in traces in suspension in the atmosphere, a profound investigation shows that they can account for no more than 0.1 to 0.2 ion per second. They do not suffice to account for the cause of the effect observed. Considering also the deposits of radio-active substances in their effect on the atmosphere, this is as variable as the deposits themselves. They might account for regular or accidental variations in the receptacles, but only of the order of 1 to 2 ions.

Finally one must consider a radiation of the soil itself in its superficial layers, with an intensity probably variable within fairly wide limits and which might correspond to 4 or 5 ions. Research has been made also as to whether the penetrating effect might not be due to radiation of cosmic origin. It is possible that such radiation exists but it does not seem necessary to invoke it to explain phenomena very near the earth's surface. It might intervene to effect ionization of high strata of the atmosphere, but even if observation had shown its existence, it may very well be left to one side for the present.

To what origin may one then attribute the spontaneous ionization that manifests itself in closed vessels, even after extreme precautions have been taken to insulate against all external radiations? There has been suggested a hypothesis of a sort of spontaneous rupture of several molecules, which, in exploding, project outside of themselves the electrons that they usually inclose. Such a hypothesis would suggest that heavy gases, the molecules of which contain a great number of electrons, ought in consequence to be more unstable and give greater amounts of ionization in the closed receptacle. It is true that while this suggestion does not come under the rating of improbable it does not seem to carry much weight. One may easily make other explanations, as for example that of Wood and Campbell, which supposes that all metals are in some degree radio-active. It would cause no astonishment to find the phenomena within the receptacle whose walls are themselves radio-active. But this again does not seem to take with the physicists, even with the extension of radio-activity to such substances as potassium and rubidium.

Under the circumstances, why not confess our ignorance and wait until decisive experiments elucidate this question, which is filled with interest despite its obscurity?

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[*] A. Boutaric, University Montpellier, in Cosmos

Railway Signals.

From the reports of the Interstate Commerce Commission it appears there are 8,312 block signal stations in the United States, of which 1,170 are operated by power. In these stations there are 142,122 operating levers, making an average of 17 levers to each station. In the operation of these stations it is recorded that last year 55,128 running signals were given, 28,969 switching signals, 3,157 "other signals." There were also made 42,011 switch movements and 27,291 derails set.

The Dawn Man of Piltdown

Was He One of the Missing Links?

The fossil human remains discovered several years ago at Piltdown Common, near Fletching, Sussex, England, have continued to give rise to considerable controversy which has taken several directions. Of first importance is the question of the age of these remains, and in considering this the suggestion that has been made that there was anything in the nature of a "plant," or a hoax may be disregarded in view of the circumstances of the discovery, but this apparently does not preclude the fact that these remains, really belonging to a much later period, may have accidentally reached the place where they were found; and the fact that there were no traces of any of the larger, and more substantial and durable portions of the skeleton, appears to have been entirely overlooked, although stress is laid on the presence of "eoliths," which this individual might have used as tools.

Another point of controversy is as to whether the

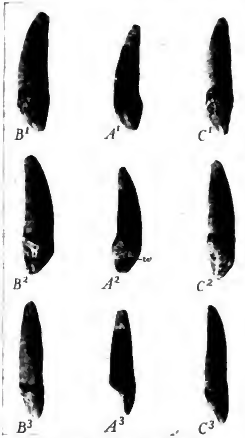

Fig. 6.—Canine tooth (cast) of the Piltdown man.

(A) In comparison with the left upper (B) and right lower (C) canines of a female orang. Natural size. The lower canine is turned upside down to facilitate comparison with the others. In A the tip of the root is restored. A^1, B^1, C^1, seen from the outer or labial side. A^2, B^2, C^2, seen from the inner or lingual side. w, worn surface. A^3, B^3, C^3, seen from the front, or antero-internally.

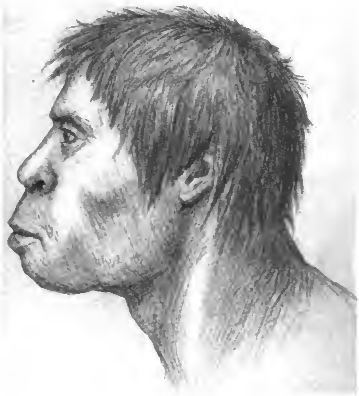

Fig. 1.—The Piltdown man in life. A restoration by Prof. J. H. McGregor.

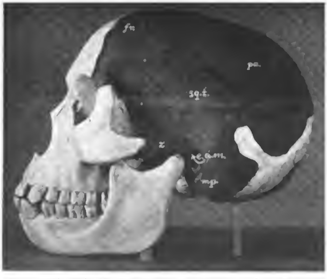

Fig. 2.—Model of the Piltdown skull as reconstructed by Dr. Smith Woodward.

Seen from the left side, one half natural size. Williams Collection, American Museum. The dark areas represent the portions preserved in the original fossil; the light areas are restored. The lower jaw (except the front part) is restored from the opposite side.

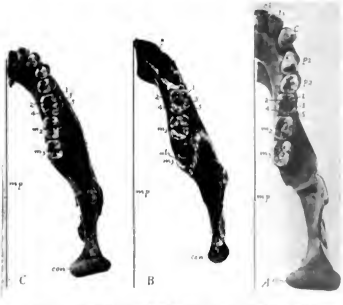

Fig. 5.—The same three specimens of Figs. 3 and 4, viewed from above.

Abbreviations as in previous figures; also, 1, 2, 3, 4, 5, cusps of the lower molars; m. p., median plane; *, broken edge.

portion of the lower jaw, and the apelike canine tooth, rightfully belong to the portions of the brain case recovered; while the main discussion relates to the reproduction, or restoration of this skull.

The facts of the discovery are these: Several years ago Charles Dawson, F.S., F.G.S., noticed some peculiar dark flints that had been used in the repair of a road near Piltdown Common that were not usual in that district, and on inquiry learned they came from a gravel bed on a neighboring farm. On a subsequent visit to this pit he secured a small portion of an unusually thick human parietal bone, and later found a larger piece belonging to the frontal region of what was assumed to be the same skull. The interest aroused by these finds led to a careful search of the surrounding soil, and of the spoil heaps from the pit, with the result that several other portions of a skull were found, as well as the right half of a human mandible and a large canine tooth; which portions have all been assembled in a restoration of the skull of what, if the asserted facts are substantiated, must have been a human being who existed in the Paleolithic Age, at "the dawn of the world," as it has been said, and at a period far earlier than any other known indications of human life.

The facts, the evidence and the arguments concerning the various features of the Piltdown specimen, which has by some scientists been declared to be a new genus of the family Hominidæ, and which has been named *Eoanthropus dawsoni*, have been collected impartially by Dr. William King Gregory, the well known paleontologist, and published in the *American Museum Journal*, to which we are indebted for the following summary and illustrations.

GEOLOGICAL AGE OF THE PILTDOWN MAN.

The question of the geological age of these now celebrated specimens is naturally of first importance. It has been suspected by some that geologically they are not old at all; that they may even represent a deliberate hoax, a negro or Australian skull and a broken ape-jaw, artificially fossilized and "planted" in the

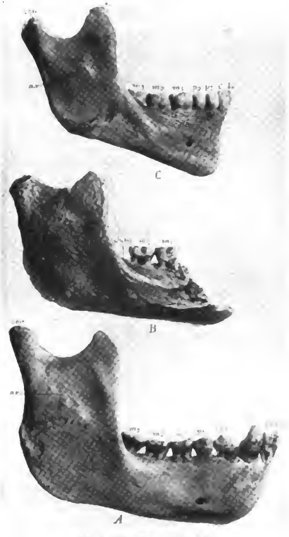

Fig. 3.—The Piltdown lower jaw.

(*B*) from a cast in the Williams Collection, compared with the jaws of a female orang-utan (*A*) and of a modern man (negro) (*C*). External views, three fourths of the natural size. Abbreviations: *alv*, m_3, socket for third lower molar; *a. r.*, ascending ramus; *c*, canine; *c. i.*, central incisor; *con.*, condyle; *l. i.*, lateral incisor; m_1, m_2, m_3, first, second, third lower molars; p_1, p_2, first and second premolars (equivalent to the third and fourth premolars of lower mammals).

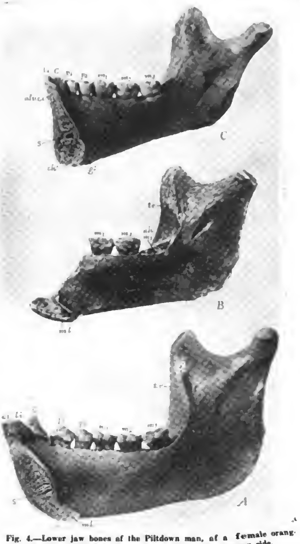

Fig. 4.—Lower jaw bones of the Piltdown man, of a female orang-utan and of a modern negro, viewed from the inner side.

Abbreviations as in Fig. 3; also, *alv. c. i.*, alveolus for central incisor; *ch.*, bony chin; *g. t.*, genial tubercle; *m. l.*, mental ledge; *t. r.*, ridge in area of temporal muscle; *s*, section through symphysis.

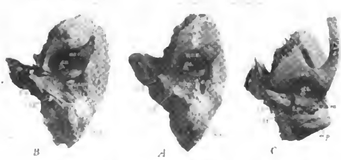

Fig. 7.—Temporal bones of the Piltdown man (A), of a negro (B), and of a female orang-utan (C). Two thirds natural size.

ar. e., articular eminence (for lower jaw); *c. c.*, carotid canal; *e. a. m.*, opening leading to middle ear; *g. s.*, glenoid socket (for lower jaw); *prt.*, bone surrounding internal ear; *st.*, pit for styloid process; *t. p.*, tympanic plate; *z*, root of zygomatic arch.

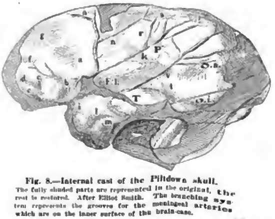

Fig. 8.—Internal cast of the Piltdown skull.

The fully shaded parts are represented in the original, the rest is restored. After Elliot Smith. The branching system represents the grooves for the meningeal arteries which are on the inner surface of the brain-case.

gravel-bed, to fool the scientists. Against this suggestion tell the whole circumstances of the discovery as above related. None of the experts who have scrutinized the specimens and the gravel-pit and its surroundings has doubted the genuineness of the discovery. All agree that the Dawn Man dates at the very latest from the Old Stone Age, and for the following reasons:

1. The dark stratum which yielded the human remains also contained a number of mammalian fossils, representing a primitive elephant (*Stegodon*), a mastodon (*Mastodon arvernensis*), a rhinoceros, a hippopotamus, a horse and a beaver. The mastodon and the stegodon belonged to species which were characteristic of the Pliocene Epoch, and on that account Prof. Keith at first regarded the human remains as equally old; but Dr. Smith Woodward and Mr. Dawson maintained that the mastodon and rhinoceros teeth had been washed into the gravel bed from an older formation, because they had been rolled and were water-worn. The hippopotamus and the beaver may be of either Upper Pliocene or Pleistocene Age. A fragmentary fossil antler of a red deer was found near by, but its association with the other remains is doubted.

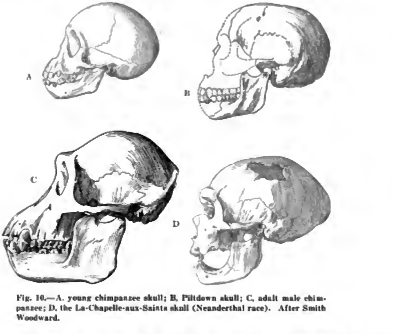

Fig. 10.—A, young chimpanzee skull; B, Piltdown skull; C, adult male chimpanzee; D, the La-Chapelle-aux-Saints skull (Neanderthal race). After Smith Woodward.

2. "Eoliths," or irregularly fractured flints, were also found in and around the gravel-pit.

3. One flint implement of Old Stone Age type was discovered *in situ* in the bed which lies immediately above the Dawn Man stratum. (See also Fig. 11.)

In brief, the discoverers of the Dawn Man finally refer his remains to the Palæolithic (Old Stone) Age,[1] but the more precise date is not settled.

The broken pieces of the Piltdown skull were compared by Dr. Smith Woodward with various human types both prehistoric and modern, and under his direction the pieces were assembled as far as possible in their natural positions and the missing parts were hypothetically restored in clay. As shown in this reconstruction (Fig. 2) these missing parts (indicated by the white areas) include the front part of the lower jaw, the lower incisors, canines and premolars, all the upper teeth and the face. Since that time the nasal bones and one canine tooth have been found.

The most extraordinary, unexpected feature of the Piltdown man, as thus reconstructed, is that an essentially human brain case, with a well-rounded forehead and with thoroughly human temporal and occipital regions, is combined with an essentially apelike lower jaw, with apelike teeth and with an apelike face (the latter hypothetical).

DID THE APELIKE JAW BELONG WITH THE HUMAN BRAIN-CASE?

Doubts and criticisms were raised at once. Doubt as to the association of the lower jaw with the skull was expressed by several authorities (Sir Ray Lankester, Prof. Waterson and Prof. Schwalbe) and is still entertained by many conservative anatomists. Did this ape jaw really belong with the human brain-case? Could an ape jaw articulate with a human jaw-socket?

Briefly summarized the principal items of evidence bearing on this question are as follows:

1. The jaw was found in the same stratum which had yielded the skull, and within a yard of the exact spot where a piece of the occipital bone was found. Subsequently the nasal bones and a canine tooth were found in the same place.

2. The jaw and skull are fossilized in the same manner and degree.

3. They were found in an ancient gravel-bed containing the débris of older deposits. "As the skull and lower jaw are very little water-worn, they would not have occurred in close association if they had been transported far from the spot at which they were originally entombed" (Smith Woodward).

4. The suggestion that while the brain-case was human, the lower jaw belonged to another creature, an ape, is not in harmony with what is already known of the fauna and climate of Europe during Pleistocene times. Thousands of mammalian remains of Pleistocene Age have been discovered in the glacial and interglacial deposits of England and the Continent, but in this highly varied fauna the anthropoid apes have always been conspicuously absent, and there is no reliable evidence that any of the race ever lived in England during the Pleistocene Epoch.

5. Fossil remains of anthropoids of any age have hitherto been exceedingly rare, and the chances that a jaw of a hitherto unknown type of anthropoid ape should be washed into the same gravel-bed with a human skull of conformable size, and that both should become mineralized in the same manner and degree, may be regarded as extremely small.

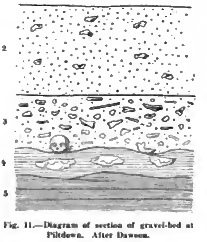

Fig. 11.—Diagram of section of gravel-bed at Piltdown. After Dawson.

1. Surface soil, with flints; thickness, 1 foot. 2. Pale-yellow sandy loam with gravel and flints. One Palæolithic worked flint was found in the middle of this bed; thickness, 2 feet 6 inches. 3. Dark brown gravel, with flints, Pliocene rolled fossils and *Eoanthropus* remains, beaver tooth, "eoliths" and one worked flint; 18 inches. 4. Pale yellow clay and sand; 8 inches. 5. Undisturbed strata of Wealden age.

6. More direct evidence that the lower jaw, in spite of its apelike features, is really that of a human being is furnished by the measurements given by Dr. Smith Woodward (*op. cit.*, p. 130). These measurements are on the whole nearer to those obtained from early human jaws than to those of full-grown apes.

7. The lower molars approach those of apes in their relative narrowness and in the large size of the third lower molar (as indicated by its alveolus), but in their flattened worn surfaces with very thick enamel they recall human rather than simian teeth.

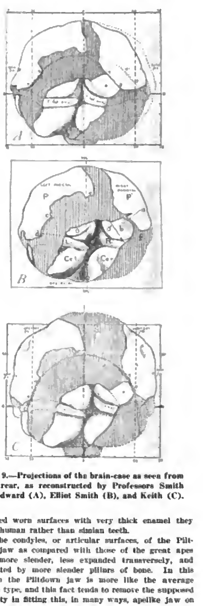

Fig. 9.—Projections of the brain-case as seen from the rear, as reconstructed by Professors Smith Woodward (A), Elliot Smith (B), and Keith (C).

8. The condyles, or articular surfaces, of the Piltdown jaw as compared with those of the great apes were more slender, less expanded transversely, and supported by more slender pillars of bone. In this feature the Piltdown jaw is more like the average human type, and this fact tends to remove the supposed difficulty in fitting this, in many ways, apelike jaw on to a human glenoid, or upper jaw socket.

9. Doubts have also been expressed as to the association of the remarkably apelike canine with the other Piltdown remains. The canine, which was discovered by Father Teilhard in the place where the other remains came from, was identified by Dr. Smith Woodward as belonging in the right side of the lower jaw; but as shown in Fig. 6, by comparison with the upper and lower canines of a female orang, its resemblances are on the whole closer to the left upper canine, as observed by Mr. A. E. Anderson. If it be an upper canine its wearing surface is such that the first lower bicuspid which occluded with it must have been elongate and prominent and much more anthropoid than human in shape. Taken in connection with the total lack of a chin, and with the straightness of the molar tooth rows, this indicates that the lower part of the face and the dentition were even more apelike than in Dr. Smith Woodward's reconstruction. If the canine be an upper one, this would tend to confirm the association of the jaw with the skull, in the opinion of American Museum collectors.

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[1] Supplementary Note on the Discovery of a Palæolithic Human Skull and Mandible at Piltdown (Sussex). Proc. Geol. Soc., London, vol. lxx, 1914, pp. 82-93.

DID THE PILTDOWN MAN HAVE A VERY LARGE BRAIN CASE?

We come now to the most controversial part of the whole subject. Did the Piltdown man have a small brain case as in Dr. Smith Woodward's reconstruction (Fig. 9A), or a very large one as in Prof. Keith's reconstruction (Fig. 9C), or one of intermediate type as in the drawing published by Prof. Elliot Smith (Fig. 9B)? Unfortunately several pieces of critical importance are missing from the middle of the skull-top and this has made possible the markedly different results of Smith Woodward and Keith. For if the remaining pieces of the skull-top are placed close together as by Dr. Woodward, the brain will be a very small one, estimated at 1,070 cubic centimeters capacity, while if these same pieces be tilted upward and moved farther apart as by Prof. Keith, the brain capacity will be as large as in many modern men, namely 1,500 cubic centimeters. The subject is an exceedingly difficult one, as the writer has learned to his cost, after long efforts to assemble the casts of the separate pieces in their natural positions. It may be briefly stated that the writer inclines to the reconstruction offered by Dr. Elliot Smith (Fig. 9B), which avoids the extreme asymmetry of the opposite halves of the brain case noticeable in Dr. Woodward's reconstruction, and gives more space at the top for the ends of the meningeal vessels. Dr. Elliot Smith has also discovered certain marks on the inner surface of the frontal bone which appear to settle the vexed question of the location of the median plane.

THE PILTDOWN MAN AS ONE OF THE "MISSING LINKS."

As stated above, the temporal bone and its mastoid process, the back of the head and the whole brain case, as well as the brain cast, are human in character, although of low type, while the lower jaw and dentition are prevailingly simian. And while this regional distribution of human and simian characters was unexpected and in a way unprecedented, it means, as Prof. Elliot Smith has noted, that the erect poise of the body, the freeing of the hands from locomotive functions, and the human development of the brain were associated in the Piltdown man with a more conservative or simian structure of the dentition and jaw.

Whether or not the Piltdown man could talk is an open question. Dr. James Robinson has pointed out that in modern man the genioglossus muscle, the principal muscle of the tongue, is differentiated into many more or less separate strands, each with its own nerve supply and that this arrangement permits the extremely rapid and delicately co-ordinated movements of the tongue in speaking, whereas in the apes this muscle is much smaller and less differentiated. In modern man the muscle is attached to two little tubercles on the inner side of the chin, known as the genial tubercles (Fig. 4, *g. t.*). In the Piltdown man, as in the apes, these tubercles are absent and the tongue rests below upon a shelf of bone. Nevertheless it may not therefore be assumed that the Piltdown man was entirely speechless. The brain cast shows in the temporal region (Fig. 8) an elliptical swelling *T* which foreshadows a certain greatly expanded center in the modern brain, a center "which recent clinical research leads us to associate with the power of spontaneous elaboration of speech and the ability to recall names" (Elliot Smith).

EVOLUTIONARY SIGNIFICANCE OF THE PILTDOWN RACE.

Assuming that the jaw really belonged with the brain case, Dr. Woodward very properly erected a new genus and species *Eoanthropus dawsoni* for the reception of this strange creature. He pointed out also that the rounded forehead with little or no brow ridges is characteristic of young apes (Fig. 10A), while the flattened forehead with projecting brow ridges is characteristic of adult apes (Fig. 10C), and also of the prehistoric Neanderthal race of man (*Fig.* 10D); he therefore suggests that the still undiscovered mid-Tertiary apes which gave rise on the one hand to the various species of mankind and on the other to the existing anthropoids probably had rounded foreheads and a relatively short face.

Prof. Keith's widely published but very questionable reconstruction showing the Piltdown man with a highly modernized brain-case has given opportunity to that part of the public which dislikes the idea of man's evolution from lower animals, to express the opinion that "the Darwinian theory is exploded." By paleontologists and comparative anatomists, however, the evidence for man's cousinship with the anthropoid apes is regarded as no longer an hypothesis.

The proof of the ascent of man from certain still undiscovered mid-Tertiary primitive apes does not rest largely upon the scant fossil remains of extinct races of men and of apes. It does rest upon the convergence of many lines of evidence offered by the embryology, anatomy and fossil history of numerous races of animals. To mention only a single line of evidence, the adult anatomy of man and of the anthropoid apes is extraordinarily similar not only in general plan throughout, but in thousands of minute details in every part of the body. By a detailed comparison of the skulls of man, anthropoid apes, and Old World monkeys and other mammals one sees directly that the human skull is merely a special modification of the primitive anthropoid type, with the brain case larger, the face shorter, the dentition weaker; but everywhere the fundamental architecture is the same. For example, consider the region of the under side of the temporal bone in man and in the anthropoids (Fig. 7); here are precisely homologous parts throughout, the same processes and ridges, the same canal for the internal carotid artery, the same styloid pit for the attachment of the hyoid bone and so forth. And so it is everywhere, throughout the skull and the entire skeleton, throughout the marvelously intricate architecture of the brain, spinal cord, and musculature, in all the vascular, respiratory, digestive and reproductive organs; so that no matter how long one continues the comparison, new similarities are constantly being revealed.

Palæontologists and comparative anatomists likewise recognize and value the differences between men and apes. They realize that even the lowest existing races of mankind are extremely superior to apes in mentality, in power of speech and in ability to use the hand as an organ of the will and intelligence. But they also believe that all these higher faculties, marvelous as they are, find their beginnings in the psychic and physical life of the apes, that the key to the mental and structural adaptations of mankind is to be found in the Primates alone among mammals.

Such being the general viewpoint of palæontologists and comparative anatomists, it need hardly be said that, to them, the Piltdown man, far from disproving the "Darwinian theory," is indeed a sort of "man in the making." He is one of the innumerable experiments made in nature's vast laboratory, an early branch of the prehuman stock which had achieved a low human stage of brain and brain-case, but which in face and dentition still bore unmistakable traces of derivation from large brained, primitive anthropoid apes.

Testing Polarity of Field Coils*

By F. A. Annett

After the field coils have been taken out of a motor or generator for repairs or rewinding, unless they were carefully marked, the electrician is confronted with the problem of getting them back in the machine with the proper polarity. In many cases, the method of procedure is to first place the coils in the machine and connect them up temporarily; then test the pole-pieces for the proper polarity, but this is accompanied usually with considerable labor, for if the electrician is unfortunate enough to have a number of the coils of the wrong polarity, considerable unnecessary labor is involved in removing and reversing them.

A better method is to test the coils before they are placed in the machine, which may be done as follows: First, place the coils and connect them as in Fig. 1, then after closing the switch to the line, test the coils with a compass for the proper polarity. The compass should point alternately north and south in adjacent coils, as indicated in Fig. 1. If a condition is found like that shown in Fig. 2, where three adjacent coils are of the same polarity—that is, *A*, *B*, and *C* are north poles, change coil *B* end for end or interchange the connections on it. This method means that coil *B* will have to be revolved through one half revolution to bring the coil terminals in the proper position to make the connections.

Again, consider a condition as that in Fig. 3, where coils *A* and *B*, *C*, and *D* are alternate north and south poles, but adjacent coils *A* and *D* are north poles and coils *B* and *C* are south poles. To remedy this condition, it will be necessary to change coils *C* and *D* end for end or interchange the connections on them to bring the four poles into the proper polarity. After the desired condition has been obtained, the coil may be placed on the polepieces just as they are located, as indicated in Figs. 1 and 4. After the coils have been located on the polepieces, they may again be tested with a compass to see if the work has been done properly.

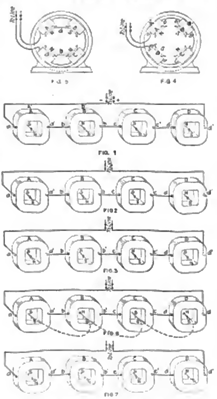
When testing for polarity with a compass, care should be taken to always so hold it that the needle is free to move, for if the compass is shifted from one polepiece of opposite polarity, if the needle is not free to move, the polarity of the needle will be reversed and will indicate that the fields are of the same polarity; this might lead one into considerable trouble. A good plan is to make the test two or three times so that the chances of making a mistake will be reduced to a minimum.

Another convenient way to test the polepieces for the proper polarity is with a piece of iron, long enough to reach from one polepiece to another and placed as shown at *a* in Fig. 5. When the poles are alternately north and south, as at *a*, the iron will be strongly attracted; if both polepieces are of the same polarity, as at *b*, the attraction for the piece of iron will be very weak, and it will be repelled when brought close to the polepieces. Care should be taken not to mistake the weak attraction which two like poles have for a piece of iron when brought in contact with them, for the strong pull two unlike poles will exert on the same piece of iron.

A good plan is to try the pull between any two poles, and if it is not very strong, interchange the connections on one coil. If the pull is increased the polarity is correct, and if decreased, the polarity is wrong and the coil leads that were interchanged should be changed back.

When a compass is not at hand for making the test as described in Fig. 1, a wire nail may be used for the purpose as indicated in Fig. 6. After the coils have been energized, if the nail is placed in one of them it will be magnetized and retain enough of the magnetism to act as a compass needle.

Care should be taken in using it as the magnetism will be easily reversed in it. Furthermore, it should be moved from one coil to another in the curved line as indicated by the dotted lines in Fig. 6. If the coils are of the proper polarity, the nail will point in the opposite direction in adjacent coils. If two adjacent poles are of the same polarity, the nail will point in the same direction as shown in Fig. 7, which can be corrected as in Fig. 2.



How to determine polarity of field coils by the use of a compass or a nail.

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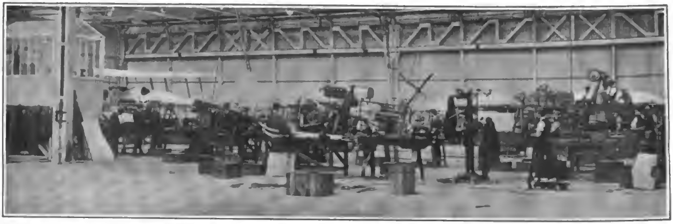
[*] Reproduced from *Power*.

Scientific Study of Aeroplanes

Few people outside those directly interested are aware of the degree of scientific study and experiment that is being devoted to flying, and that there are already in existence a number of great aerodynamical laboratories which have done much valuable work. The oldest of these is at Koutchino, Russia, under the direction of Dr. Riabouchinsky. At Paris is the laboratory of M. Eiffel, where this famous engineer has for a number of years carried out most valuable researches. Paris possesses another laboratory, planned on an ambitious scale, founded at St. Cyr through the generosity of M. Deutsch and controlled by the University of Paris. At Rome there exists a well-equipped laboratory belonging to the Italian Aviation Corps, and finally there is the admirable aeronautical section of the National Physical Laboratory at Teddington.



One of the shops of the Royal Aircraft Factory at South Farnborough, England.

A Visit to the Royal Aircraft Factory

Where the British Government Develops its Air Scouts

By Brigadier-General F. A. Stone, Late R.A.

By permission of the War Office and by the courtesy of the superintendent, Mr. Mervyn O'Gorman, I was enabled recently to spend a most interesting and profitable day at the Royal Aircraft Factory, South Farnborough.

The duty of the factory is not only to design and construct experimental aircraft and the attendant instruments, engines and appurtenances for the army and navy, but to make a certain limited number of each type with a view to developing its designs till they are suitable for manufacture by private aeronautical constructing firms.

Aircraft of original design, purchased by the government from outside sources, are submitted to the same severe tests by the inspection branch as the government machines, before being passed into the service, for use by the officers of the Royal Flying Corps; if they do not satisfy the test for the minimum factor of safety, they are not passed into the service; it may be observed that the Aircraft factory machines have a high safety factor.

One thing is quite clear, viz., that the officers of the Royal Flying Corps have nothing to fear in regard to structural weakness in any machine passed out of the Royal Aircraft Factory, and may indeed feel additional confidence in those machines which have been constructed to the Aircraft Factory specification.

There are three standard designs now being manufactured:

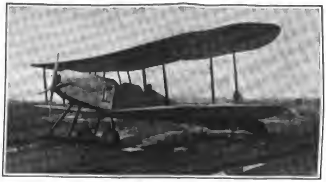
1. The one-seater scout (S.E.) for fast work of a special nature, in which speed is the predominating factor, and this type is only used by the more experienced pilots. Of course the principal difficulty with such machines is to learn to fly them slowly for landing. The tractor screw is in front.

2. The two-seater reconnaissance machine (R.E.) (formerly called B.E.) for the normal work of reconnoitering. This machine has the tractor screw in front also; the engine is in front; the observer is seated in front of the pilot, and the planes are slightly staggered. The aeroplane design gives a variation in speed of nearly 40 miles an hour between maximum and minimum. A Renault engine of 70 horse-power is used, but the original design was evolved on a Wolseley engine of the same power with excellent results. There are a number of vertical fins on the upper surface of the top plane of the latest machine, designed to give automatic lateral stability; these fins are a special feature of the machine, their area and design have been calculated with mathematical precision, and may be said to achieve the same end, which was more roughly aimed at in the old cellular type of Voisin machine. The landing chassis is also a special feature, the two skids being rendered rigid laterally by an ingenious

Main shop of the Royal Aircraft Factory at South Farnborough, England, where the British Government is developing and building flying machines for military purposes.

and original system of stays, without any cross transoms which would interfere with the free running of the skids on rough ground or crops.

This machine is very fast and safe. Mr. Henry Farman was much astonished at seeing a comparative beginner flying on one of these machines in a 50 miles per hour wind, and he asked whether the pilot was an old hand, and could scarcely credit the fact that this type of machine was so stable that it was perfectly safe for a comparative tyro under conditions which would prevent such a pilot from attempting a flight on almost any other type of machine. In this connection it is also necessary to bear in mind the immense advantage given by the wide range of speed variability.



New reconnoitering biplane (R. E. class) built at the Royal Aircraft Factory.

3. The latest type is the fighting machine, which carries an automatic gun in front. In this case it is necessary to have the propeller in the rear instead of a tractor screw in front: the gunner is seated immediately behind the gun, and in front of the pilot.

Both this type and No. 2 can carry armor, and are also designed so that every strut and stay is duplicated, in such a way that the shattering or severing of any wire by a rifle bullet or the perforation of a spar will have no effect on the efficiency of the structure; I do not mean that *doubled* struts or wires are used, but that the design is so worked out that every strain is borne by more than one *system* of support, and that no individual stay is in itself indispensable.

Silencers cannot be fitted to rotary engines, such as the Gnôme, and that this is a drawback cannot be denied; but the other good qualities of the Gnôme engine keep it still to the front, though there is another rather serious drawback to the use of all but the very latest type for military purposes or for long-distance flying, and that is its extravagant consumption of lubricating oil. The new monosoupape type is claimed to have entirely overcome this.

Self-starters are in the design of all the recent Royal Aircraft machines, but when it comes to turning out the complete machine it has generally been found in the past that the self-starter has to give way to something else which, for the present at any rate, is considered a more useful way of employing the weight.

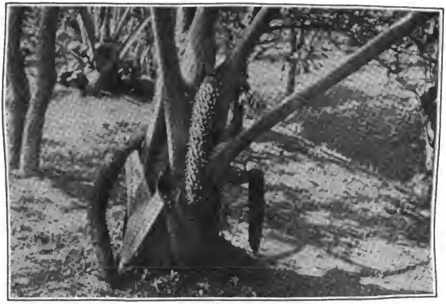
With regard to future developments, the cheery optimism of Mr. O'Gorman, based as it is on exact scientific knowledge and training, and unique experience of up-to-date work and practical achievement, fills one with confidence, not only as regards the extended scope of aviation for military purposes, but also as regards its commercial value. Mr. O'Gorman contemplates, as a reliable ideal, the transport of field guns by weight-carrying aeroplanes, with a view to opening fire on an enemy with artillery under circumstances which would have precluded the aid of the guns under ordinary conditions of transport. He is also sanguine as to the early employment of aeroplanes by the post office, and for commercial purposes. As regards the latter, it is a little difficult for soldiers, who are rather out of touch with the bustle of commercial life, to realise the importance of saving 24 hours in the delivery of certain commodities. Women's fashions alone offer a field for this class of enterprise. It is only necessary to recall the tea clippers in the middle of the last century to understand what lengths those engaged in certain branches of the carrying trade will go to, in order to deliver goods earlier than their rivals. These ships were as well found in every respect which mattered for speed as any first-rate racing yacht; their sails were frequently of silk, and no expense was spared to secure the highest possible rate of speed and the quickest run, to land the first tea crop of the season.

The Double Cocoanut Palm

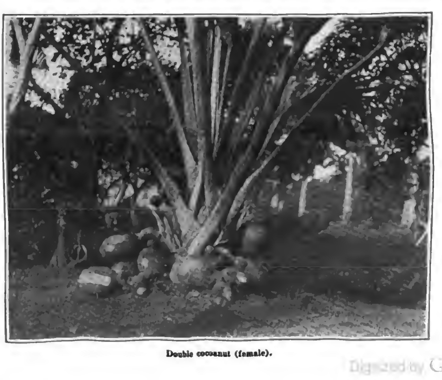
The accompanying illustrations show the male and female trees of the double cocoanut palm growing in the botanical garden, Georgetown, British Guiana. This is not the true cocoanut (*Cocos nucifera*), but an entirely different species (*Lodoicea sechellarum*), which is native to several small islands of the Seychelles group lying just east of Madagascar in the Indian Ocean. The young palm trees shown here were raised from seed brought from the Seychelles, and they are now about twenty-five years old and are just beginning to bear fruit.

This palm, which the English people call maldive nut tree and the Portuguese coco de mer, produces the largest known fruit in the world. The fruit was known many years before the tree on which it grows. Portuguese sailors first found these immense woody nuts floating on the water in the neighborhood of the island on which the palm grows. For many years the sailors, as well as botanists, believed that these nuts were the fruit of enormous sea weeds growing in the deep water of the Indian Ocean, but in 1780 it was discovered that they were the product of a magnificent palm tree growing only on the Islands of Praslin and Curieuse. The empty shells, or occasionally the unsprouted fruit of this palm, are washed down the streams into the ocean, and a few nuts were fished up by the sailors and brought to Europe as a great curiosity in the sixteenth century.

The double cocoanut palm does not produce flowers until it is about twenty years old, when the male tree puts forth catkins which are about three feet long and three inches in diameter; the female tree produces a zigzag stalk on which the flowers are arranged alternately, and on which a few, or sometimes as many as eleven nuts are borne. These nuts are brownish-black



Coco de Mer, or double cocoanut (male).



Double cocoanut (female).

in color, often over a foot long, nearly as thick, and deeply bifurcated. The shell is very hard, strong, and resists decay to a remarkable degree. The inner portion is fleshy and consists chiefly of albuminous matter which represents the accumulation of years, for the seed requires from seven to ten years to mature. The fruit is full grown at the end of four years, when it is soft and filled with semi-transparent jelly-like substance. The fully matured nuts weigh about forty pounds.

The albuminous substance in the interior of these large nuts was at one time believed to contain medicinal properties, and fabulous prices were often paid by rich Indian princes for a single nut. The active principle was employed chiefly in counteracting poison, but it has long since lost much of its repute, except with a few of the poorer classes of the Seychelles Islands. It is used at present in India, where it is still looked upon as a curative and preventative for a good many dreaded diseases. At one time a single nut cost as much as $500, but at present they can be bought for less than a dollar.

The double cocoanut palm does not attain maturity before it is one hundred years old. The male trees produce a cylindrical stem about one foot in diameter and upward to twenty-five feet from the base to the crown. The crown is composed of a dense mass of large fan-shaped leaves twelve to fifteen feet long. The female trees are always smaller. The wood is exceedingly hard, heavy, strong, and almost indestructible. It is used largely in the construction of houses and for other purposes requiring a durable wood. Their chief use is for roofing and siding of houses, but large quantities are employed also by native women in making beautiful wicker work, which is embroidered with silk from Madagascar. The use of the wood and of the top has been so great in recent years that the English government has now taken steps to preserve the remaining trees in the few small localities where they grow naturally. The leaves are almost as valuable as the wood to the natives, who make use of them for a great variety of purposes.

Feeding the German People in Time of War

Discussed by a German Authority Before Hostilities Were Declared

How LONG could the German Empire feed its population from domestic products alone in case her enemies could so forge that "iron ring" of which we have been hearing so much as to cut off all importation of provision for man and beast? For a number of years the subject has been much discussed, not only by Germans, but by French and English writers as well. The events of the past few weeks have suddenly made it of practical and portentous interest. Writing last March in the *Preussische Jahrbücher*, Count von Moltke took a distinctly optimistic attitude. While denying the probability that her ports could be completely blockaded, he declared Germany could long support her people by the products of her own soil.

In the July number of the same magazine a very opposite view is taken by one of the most prominent publicists in Germany, Dr. Carl Ballod, *Ordentliche Honorarprofessor* of the University of Berlin. Fifteen years ago, declares Dr. Ballod, there might have been reasonable hope of success by taking prompt and energetic measures, such as the deflecting of grain from the hands of the distiller and the brewer to those of the baker. To-day, he declares emphatically, this is no longer possible. It is true that the imports of bread grain have fallen off of late years, and this year Germany has even been exporting a large number of tons of rye instead of importing it as in the 90's. But Dr. Ballod properly lays stress upon the fact that the amount of bread grain imported or exported is only one factor in the problem, and that no just conception of the situation can be arrived at without considering it in connection with the total consumption of all grain, fodder, oleaginous foodstuffs, etc.

"The importations of bread grain are diminished," he states, "but the total importations of grain and all foodstuffs have tremendously increased. In 1911-1913 we imported about 10,000,000 tons of grain and fodder, and also at least 5,000,000 tons of *grain equivalent* in the shape of 900,000,000 marks' worth ($225,000,000) of cattle, meat, tallow, herring, eggs, butter, and cheese. Even if we accept the German harvest statistics as absolutely correct—26,000,000 tons net for 1911-1913—it will be seen that a full third of the grain needed for food was imported. . . . It is therefore a fearful self-deception to estimate that the German nation can amply supply itself with the bread grain needed for eleven months in the year. Amply! Yes, so long as 60 per cent of the fodder required by the necessary cattle can be imported! The cutting off of fodder importation means a decrease in the milk yield to three fourths as much at the most, while in swine-breeding the consequences would be nothing short of a catastrophe; two thirds of the pigs and young hogs could not be fed, but would have to be slaughtered as soon as possible.

"Hence, cutting off importations of food means a decrease in the consumption of animal food by one half, and consequently a crying need of increase in bread consumption."

Dr. Ballod here interpolates a scathing criticism of the method of obtaining statistics of grain yield in Germany, which he considered far less accurate than that of England. He concludes that the crops statistics are overestimated by 15 per cent on an average for the whole empire. This would reduce the yield for 1911-1913 from 28,000,000 tons to only 23.8 million tons gross, or 21.7 million tons net. He acknowledges, however, that the enormous yield of potatoes, over 40,000,000 tons net, in the last three years is an important factor in the feeding of the population, but says the nutritive value of the potato should not be exaggerated, as has been done by Behrend. His remarks on this point are of general interest. He says:

"The potato is a *one-sided* food; it contains, according to Kellner's tables (the only ones now used), 15 to 19 per cent of starch, but only 0.2 per cent of albumen and 0.1 per cent of fat. Hence, the ratio of starch, albumen, and fat is as 170:2:1, whereas the human requirement of these food elements is as 10:2:1, and the requirement of animals is not very different. Advantageous as is the process of drying potatoes, by way of preserving large quantities which would otherwise rot, it does not solve the problem of the nutrition of man and beast, since for rational nutrition additions of albuminous and of fatty foods are unconditionally required. That potatoes can be used to replace part of a horse's rations of oats, when the animal is not working, is true, but every farmer reduces the oats ration for idle horses in any event. Hence, if by the general introduction of potato drying 10 per cent of the crop now lost could be saved, i. e., about 4,000,000 to 5,000,000 tons, this would be a great achievement; but we must not forget that this 4,000,000 to 5,000,000 tons of potatoes is the equivalent of only about 1,000,000 tons of wheat or energy-yielding fodder, while we import tenfold that amount. Indeed, it might even be maintained that the more potatoes were thus saved, the more need of importing foods containing albumen and fats, as otherwise the excess of potatoes would not be balanced.

"To be sure, we could raise in the interior greater amounts of albuminous and oleaginous crops—beans, vetches (wicken), flax, turnips, (rübsamen), but this could only be done by cutting down the area devoted to grain and potatoes, which would hardly be rational.

"Count Moltke dilates on the fact that great quantities of our own wheat and rye are, in times of peace, made to serve industrial ends by transformation into grain alcohol, starch, etc., and therefore withdrawn from consumption as food. It is worth while to inquire into the amount of these quantities. In 1909-1910 it amounted to 341,000 tons, and in 1911-1912 the amount had risen to 600,000 tons, but this was because of the failure of the potato crop."

Prof. Ballod then raises the question whether the total food value of the grain and potatoes usually distilled would be gained as an extra supply of nutrition in case breweries and distilleries were put out of commission. This portion of the article is of peculiar interest in view of the fact that recent dispatches stated that the German government had already diverted 40 per cent of distillers' supplies to nutritive purposes. Prof. Ballod reminds us that half of the nutritive value of the grain remains in the refuse or "slops" from the stills. Moreover, it is the most valuable half, since it contains almost the total content of albumen and fat—the very elements which would be most needed in case imports were checked.

Prof. Ballod continues: "It is still an open question whether an increase of food would not be necessary if the consumption of alcoholic liquors, etc., ceased. For, though alcohol be not a food, yet, according to the prevailing view to-day, its use lessens the amount of food required. It is even more problematic whether gain of nutriment would result from closing the breweries."

Another point raised by the author is that total abstinence forced on a people used to moderate indulgence in alcoholic drinks might cause widespread mental depression, and he remarks that "mental depression alone is capable of losing battles!" Furthermore, he says: "It is well known, for example, that certain polar explorers like Nansen, who boasted of having used no alcohol on polar expeditions, found that all the members of the party fell into a very gloomy frame of mind. On the other hand, in the German South Polar Expedition, the men's spirits were excellent, which is attributed to the fact that a moderate ration of alcohol was allowed."

Even more drastic is Prof. Ballod's criticism of Count von Moltke's comfortable, but, as it now appears, mistaken assumption that Germany's frontiers and ports of entry could never be completely blockaded, and that, even if they could, she possesses abundant means to feed the populace. He says emphatically:

"I am sorry to be obliged to contradict this optimistic view most decidedly. It is far more true that the provisioning of the population would be seriously endangered. In the first place, it is absurd to say that such a blockade could never be made complete. Does Count von Moltke believe that the Belgian, Dutch, Danish, and Swedish harbors would remain open in the worst case conceivable, that of the Triple Entente against the Triple Alliance? That England, after war had been declared, would permit her merchants and shipowners to shower food upon us via Holland? English writers hold other views. They say openly they could starve out Germany. Note also, that to cut off food from Germany, England would not even have to violate the neutrality of Belgium and Holland. Two thirds of the grain boats which go to their ports are English, a fact German writers do not seem to know. The English government need merely order English ships to remain in their harbors. . . . Moreover, Belgium must herself buy 2,500,000 tons of grain to supplement her own crop of 1,500,000 tons, while Holland buys 1,500,000 tons to supplement her own 1,000,000 tons. Hence, the neutrality of Belgium and Holland is worthless."

Dr. Ballod then gives a valuable summary of the crops and imports of grain of various countries even more interesting now than when written. Switzerland produces a quarter of a million tons and imports three quarters of a million tons, half of which is wheat. She draws from Mannheim, Genoa, and partly from Hungary. Austria-Hungary in ordinary years has no excess, and in bad years, such as 1909, must import three fourths to one million tons of wheat! Italy imports, of wheat alone, 1,250,000 to 1,500,000 tons, which is why English favor is a matter of such importance to her. Rumania? Yes, if we were sure of her . . . in good years she exports 2,000,000 tons, equal to one fourth to one fifth of the necessary German importation. But Rumania has become uncertain as regards us. Denmark? The *hostile* neutrality of Denmark is obvious. Sweden-Norway? Sweden imports one fourth of the bread grain she needs, and Norway three fourths of her needs. Both largely depend on Germany for rye. Of course, the neutral grain boats in Norwegian ports could be ordered to bring grain to Germany, in which case Bergen, Drontheim, and Narvick would be the ports, in case England permitted the Norwegian merchants to reap this rich harvest of trade and the grain was sent to Trelleborg and from there on German boats to Stettin or Lübeck.

"But for this purpose the hundred grain trains of thirty cars each must travel daily 1,400 to 2,000 kilometers over mountains that rise into the 'eternal snows.' Is this technically practicable? The roads of Sweden and Norway are one-tracked, and even if it were technically possible, it is a dead sure thing that England would quickly put an end to this traffic. . . . The case does not look very rosy for Germany. But it is a major concern of the state not to allow half the population to starve, as they did in the Thirty Years' war. The maintenance of the population, at the least *in statu quo*, is the most distinguished achievement of the statesmen, aside from ethical reasons. . . ."

After completing these highly pessimistic observations, Dr. Ballod asks what could be done, and proceeds to follow his destructive criticism by constructive suggestions. Remarking coolly that the civil population could not expect to receive its full normal rations, he continues:

"In the first year of war the consumption of meat and milk would be cut down to 75-80 per cent of the normal, even in case all the young cattle and three fourths of the swine were slaughtered to save feed. All the more care would have to be taken not to cut the bread allowance, so that the highly nutritious almal food might be, at least in part, replaced by vegetable food (bread). Rye and wheat might be more exhaustively milled, reducing the customary 25-30 per cent of bran to 5 per cent. . . . But we must not forget that the albumen of bran can be utilized only by the animal stomach and not by the human; thus a part of this important animal foodstuff would be diverted and serve merely to fill men's stomachs without nourishing them."

The real safeguard, he contends, is the laying up of stores of bread grain in times of peace so as to be ready for war. Thus does a brilliant, modern economist take a lesson from Joseph, the Israelite, who in the fat years of Egypt stored grain for the lean years! Dr. Ballod thinks it advisable that even in times of peace it is well to keep stored at least 2,500,000 tons of grain. He would have great granaries built in the large cities and regions of supply. Another reason for this is that after the outbreak of war train service is absorbed by mobilization. These granaries should each hold about a year's supply for the region served. Such regions of supply are the territory of the Rhine, of Rhinish Westphalia, Hessen-Nassau, and South Germany. "The latter brought in by water a surplus in 1909-1911 alone of 1⅝ million tons, of which 1⅛ million tons were wheat and ½ million tons rye. . . . Under present conditions an outbreak of war would, within a few weeks, spell catastrophe for the industrial population of West Germany. In a short time the price of bread would rise to a figure prohibitive to the mass of the population."

In such a pass he considers the only remedy would be for the state to confiscate all grain, as in the siege of a fortress, and deal out rations proportioned to the amount of provisions on hand, adding with sinister emphasis, that a great infant mortality could not be avoided, and that doubtless the dreaded "hunger-typhus" would claim many victims.

"The better way, true statesmanship, would be to make preparation beforehand . . . like Frederick the Great, who by a shrewdly planned system of magazines not only kept his army in fighting trim, but kept the civil population at least *in statu quo*, despite the suffering in Silesia, during the Seven Years' war, while in the neighboring territories of Austria starvation claimed dreadful sacrifices."

The next point considered is the number of men who would be called out and the industrial disturbances and changes consequent on this as well as in the cessation of import and export traffic, the closing of factories, etc. He takes a very lugubrious view of the result as liable to turn back the hands of Germany's marvelous progress some two hundred years and putting her at a lower point commercially than such small countries as Finland, Switzerland, or Belgium. He says:

"It is obvious that in a great war, waged for the very existence of kingdoms and nations, every available man must be called out." Here follow statistics as to the men subject to military service. Excluding aliens, there are about 9,000,000 males between the ages of 20 and 39, and of these he estimates that there were, at the end of 1913, 4,900,000 who had the proper military training. Of these, he says 3,300,000 would doubtless be sent to the front, and 1,600,000 at most retained as reserves.

"All trades would be seriously affected; agriculture least, but even so, agriculture would have to count on losing 1,000,000 active wage-earners, and it is a question whether those left could maintain intensive culture at the point to which it has at present attained."

However, he suggests that the proportions of the crops could be altered to suit the most crying needs, provided, of course, that the war broke out early enough in the spring to make the change in acreage and that enough seed-grain were on hand.

The "heavy" industries such as mining, foundry work, and machine making, would lose 30 to 35 per cent of their strongest men, but the textile industries would not be severely drained. Building would cease, so there would be less demand for iron and coal, but the textile industries would be forced to stop work in a few weeks because of the lack of raw material.

"Silk and cotton factories depend entirely on foreign imports and there are practically no stores on hand. The wool and flax industries to-day import nine tenths of their raw material from foreign countries. Things were very different in 1870. . . . However badly the military authorities needed clothes for troops, they could not be provided when the uniforms now on hand are exhausted. Hence, provision should be made for storing rawstuffs at least sufficient to supply the reserves with uniforms, and for sweaters in case the war last into fall and winter. . . . The civil population can wear old clothes if need be; the soldiers must have plenty of clothes, and warm ones."

Another suggestion he makes is that by a system of organized credits electrical firms and those making agricultural implements might be enabled to furnish great quantities of reaping machines, electric plows, and potato harvesters. Thus many of the unemployed would find work, the vital interests of agriculture would be served, and the oxen now employed for farm work could be sent to the butcher, which would furnish extra meat and also save fodder for the milk-cows. But he fails to show how a destitute population is to obtain and operate these expensive implements.

After declaring that Germany has much to learn in the way of efficient economic preparation, he utters this pregnant warning:

"Not only adequate or inadequate military preparation, but adequate or inadequate economic preparation will chiefly decide victory or defeat, or even the existence or non-existence of states and dynasties."

Vital Processes and Physics*

The general distinction between the "descriptive" and the "exact" natural sciences is that the former are concerned with phenomena, the latter with the causes of natural processes. The two fields overlap in many parts, but not so extensively as is desirable and even possible in the present state of science. The most important work in overlapping regions has been accomplished in dynamic geology, and, following the initiative of Julius von Sachs, in vegetable physiology.

In the science of the vital properties of animals and men, investigators endowed with the erudition and ability of Helmholtz and A. Fick have always been rare, and in pathology, the science of the behavior of morbid organisms, very little has been accomplished in the certain and quantitative assignment, by scientific methods, of causes to observed events. The chemical processes of life were the first to receive serious, though inadequate, study; the phenomena most neglected are those of motion, which are so abundant in the records of the descriptive sciences.

For every action a cause must logically be assumed, and the cause of any motion or change of motion is called force. Here lies the field in which the co-operation of descriptive and exact science is now most urgently needed, and it is incumbent on the representatives of each branch to study and learn the other more thoroughly than they have done hitherto.

The phenomena of motion in living organisms that have been accurately observed and described are manifold and almost innumerable. It would be a very good thing to take up at last the important task of discovering the cause of these motions, which can be nothing else than a force. In this work, as in physics, the science especially concerned with motion, the most valuable aid will be furnished by mathematical analysis. The physicist deals with problems which either are comparatively simple in themselves, or can be so simplified by an ingenious plan of experiment that they can be treated mathematically. The field of the physicist is strictly confined to inanimate nature.

Animate nature exhibits many phenomena of motion that are far too complex for mathematical treatment at the present time; but it also presents more simple phenomena, which are quite amenable to such treatment. In any case it is possible to find among known forces of nature one to whose action the observed phenomenon may be chiefly assigned. Whether it is a force that acts only at intermolecular distances, such as osmosis, imbibition, surface tension, thermal expansion, etc., or a force that acts at greater distances, such as gravitation, electricity, or magnetism; this, at least, can certainly be determined. In my opinion, researches of this character should soon form an important part of biological work. They will require some preliminary education in physical science, which will perhaps make such vague expressions as "electric charge" and "magnetic attraction" less common than they are now.

When Woehler, in 1828, synthetically produced urea, a chemical compound then known only as a product of the animal organism, a powerful impetus was given to the development of organic chemistry. Already the carbon compounds that can be made artificially are far more numerous than those known to exist in nature, and no one can doubt that the same chemical laws govern the organic and inorganic worlds. This conviction has given the death blow to the old doctrine of "vital force," and it has been assumed that the organic and inorganic worlds are also moved by the same physical forces. This impulsion, one might almost say compulsion, toward unity has greatly promoted the development of the natural sciences. Every research, if it is to be truly scientific, must aim at the demonstration of this unity, especially of effective forces, in each individual case.

If this cannot be accomplished, it is certainly better to doubt one's own ability or the adequacy of the methods employed than to doubt the unity of natural forces. But even here there is a limit, and genuine science must not be afraid to break with the most firmly founded assumptions if they are found at variance with certainly demonstrated facts.

If the biologist, not content with describing movements and designating them as expressions of life, seeks their causes and finds that known physical forces are insufficient to produce them, then, and then only, the action of a "new force" may, or rather must, be assumed. This has always been done in physics; for example, when electrical phenomena were first observed. It must be proved, however, that the new force is competent to produce the observed movement and, even then, the new force must be cast aside as soon as anyone proves that it is superfluous and that the movement can be produced by a combination of known forces.

Both conditions, positive and negative, are satisfied in the case of an inconspicuous movement, observable only under the microscope, that accompanies the fertilization of the egg of the star-fish.[1] All known physical forces can be excluded with certainty, and the observed phenomena accord, with astonishing exactness, with the theory of a new force which, like gravitation, is universally proportional to the square of the distance. Although new force is dependent upon the life of the masses from which it emanates and upon which it acts, it is not a mysterious "vital force," but a force as real as gravitation. It is not likely that the action of the new force is restricted to the single case that has been observed. Probably many other instances exist in the organic world, but they can be discovered only by biologists who possess the requisite knowledge of the exact sciences.

The mind revolts at the idea of a real physical force that acts only on living matter and is extinguished with life, but the contrast between this and other physical forces is no greater than the contrast between life and death, in general.

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* Translated from Richard Geigel's article in *Die Umschau*.

[1] Arch. f. mikroskop. Anatomie, Bd. 80, Abt. II, S. 171, u. Bd. 84, Abt. I, S. 483.

Wreck Statistics for 1913

The statistical summary of vessels totally lost, broken up, condemned, etc., now published by Lloyd's *Register*, shows that during 1913 the gross reduction in the effective mercantile marine of the world amounted to 665 vessels of 717,030 tons, excluding all vessels of less than 100 tons. Of this total, 371 vessels of 533,002 tons were steamers, and 294 of 184,028 tons were sailing vessels. These figures, as regards steamers, are lower than those for 1912 by 30,543 tons; but as regards sailing vessels, they are for the year 1913 somewhat higher, viz., by 7,808 tons. One of the most common terminations of a vessel's career is breaking up, dismantling, etc. (not in consequence of casualty). The amount of tonnage so dealt with in 1913 was 108,795 tons, this being 48,846 tons less than that for 1912. Nearly 20½ per cent of the steamers and 16 per cent of the sailing vessels removed from the merchant fleets of the world in the course of 1913 are accounted for in this manner. Of the total tonnage of such cases 42¾ per cent is represented by United Kingdom vessels. The statistical tables exhibit interesting data as to the relative frequency of the different kinds of casualty, etc., which conclude the existence of vessels. Stranding and kindred casualties which are comprised under the term "wrecked," are much the most prolific cause of disaster. To such casualties are attributable over 58¼ per cent of the losses of steamers, and over 54 per cent of sailing vessels. Cases of abandoned, foundered, and missing vessels are no doubt frequently more or less similar in the circumstances of loss. If these be taken collectively, they form about 21¾ per cent of the steamers, and over 29 per cent of the sailing vessels removed from the mercantile marine during 1913, owing to casualty.—*Marine Engineer and Naval Architect.*

The Future of Engineering Progress

If progress continues along the lines now followed by pure and applied science, it is predicted by Prof. A. Ranum that it will surely lead to practical applications and new inventions that will startle the world. The material and utilitarian progress of to-morrow will depend largely on the scientific progress of to-day. Moreover, increased accuracy and efficiency in engineering can be met only by broadening and strengthening its mathematical foundations. Many an engineering student of to-day will live to see the time when those engineers who are leaders in their profession, who are capable of meeting novel conditions where originality of thought and action is required, will be men who are thoroughly trained in the use of many of the higher branches of what we now call pure mathematics.

NEW BOOKS, ETC.

Pattern-Making. By Frederick W. Turner and Daniel G. Town. New York: John Wiley & Sons, Inc., 1914. 12mo.; 144 pp.; illustrated.

Written for use in vocational and industrial schools, this text outlines the materials, tools, and processes of pattern-making. It is a primer of the trade, designed to open the way to such books as can appeal only to one who has mastered the elementary practice.

Crop Production. An Agricultural Text for Schools. By Clarence M. Weed and William E. Riley. New York: D. C. Heath & Co., 1914. 12mo.; 246 pp.; illustrated. Price, 75 cents net.

In a beautifully illustrated text the authors set forth the nature and requirements of vegetable, flower, fruit, and farm crops. The work employs what is known as the "project method," replacing symbols by realities and furnishing the teacher with many simple outlines preliminary to the text.

Second Course in Algebra. By William Benjamin Fite, Professor of Mathematics in Columbia University. New York: D. C. Heath & Co., 1914.

Students who have already taken the year's course for beginners will find in this text-book a review of first-year subjects and a logical development of the study that will take them through their second year and fit them for passing college entrance examinations in the subject. Abstruse and complicated problems are avoided; those referable to physics and geometry are given preference. Ratio and proportion is dealt with under fractions. In treating of the loci of equations of the second degree in two variables, the simpler cases only have been noted.

Preservatives and Other Chemicals in Foods. By Prof. Otto Folin, Hamilton Kuhn Professor of Biological Chemistry in Harvard University. Cambridge: Harvard University Press, 1914.

Prof. Folin's little book on "Preservatives and Other Chemicals in Food" is one of a series of Health Talks, setting forth in a popular way the substance of some of the public lectures delivered at the Medical School of Harvard University. It contains much valuable information on the methods of preserving perishable foodstuffs, beginning with the old family practice of the application of heat or cold, down to the extensive use of chemicals in our modern canning and cold storage industries.

The fundamental problem of preserving foods, and one which for twenty years has confronted the scientists engaged in finding a proper solution of this problem, meant the making of that food unfit for bacteria to live in, but still fit for human consumption; this necessitated much experimenting with various chemicals and delving into the science of bacteriology. The new methods thus evolved after long years of hard work and exhaustive research, were unfortunately not left in the hands of these disinterested investigators, but they became money-making schemes seized upon by men whose main interest was a pecuniary one.

Prof. Folin comments at some length on Dr. Wiley's long and untiring fight against the indiscriminate and unscrupulous use of chemicals in foodstuffs. Rather unique is his idea of the best method of observing the effect of these "preservatives" on humans. He advocates the trying out of various substances used in preserving foods on the inmates of prisons, not because they are prisoners whose fate or health is of little consequence, but because they are the largest body of persons available whose habits are essentially regular and uniform, and whose health record could easily be kept for a long period of years.

The Polytechnic Engineer. Published Annually by the Students of the Polytechnic Institute of Brooklyn. Vol. XIV., 1914. 8vo.; 164 pp.; illustrated. Subscription price, $1.25 per copy.

This is an annual having for its chief aim the encouragement of undergraduates in the writing of scientific articles. About half the papers in this issue were written by the faculty; the other half are the work of undergraduates and the alumni. These papers are informative upon such subjects as underground construction, industrial illumination, street planning, the valuation of railway property, and the determination of stress. They exhibit varying degrees of interest and usefulness, and altogether make up a creditable collection.

Science and Religion. The Rational and the Super-rational. An Address Delivered May 4th, 1914, before the Phi Beta Kappa Alumni in New York. By Cassius J. Keyser, Ph. D., LL. D., Adrian Professor of Mathematics in Columbia University. New Haven, Yale University Press, 1914. 12mo.; 80 pp. Price, 75 cents, net.

The author has perhaps wisely omitted to give us his own definition of religion, although it is difficult to follow and appraise arguments for or against a state of consciousness represented by a word meaning different things to different men, unless the word is defined rather strictly for purposes of discussion. Broadly, the writer supports a belief in the super-rational, strictly limiting the rational and placing the vitalizing element of religion above reason's plane. The address is an admirable piece of work, a striking example of the academic style at its best. While we may not always be able quite to make our footprints coincide with those of Prof. Keyser, we set our face toward the same goal. He has given us a well-proportioned construction of modern thought, invigorating in its procedure and sound in its deductions.

The Hydrogenation of Oils. Catalyzers and Catalysis. The Generation of Hydrogen. By Carleton Ellis, S. B. New York: D. Van Nostrand Company, 1914. 8vo.; 425 pp.; 145 illustrations. Price, $4 net.

The oil industry has such important outgrowths and ramifications that a work amalgamating the scattered literature of hydrogenation and allied processes should be welcomed by all who are in any way interested in these subjects. The author very fully explains the methods of hydrogenation, and their application in the fields of food manufacture, soap making, etc. The work concludes with a chapter on safety devices and some citations from patent litigation. Both student and worker may benefit by the wide range of information, the processes and the suggestions contained within this volume.

The Question of Alcohol. By Edward Huntington Williams, M. D. New York: The Goodhue Company, 1914. 12mo.; 121 pp. Price, cloth, 75 cents; flexible leather, $1.25.

These papers embody a protest against the exaggerated teachings of the school text-books for it is the opinion of the writer that these exaggerations defeat their own purpose. Indeed, this position is defended by statistical deductions. Liquor legislation is also censured, and is held responsible for the alarming increase in whisky drinking and drug taking. The little volume is not, however, merely destructive and reactionary. It makes sensible suggestions toward remedying existing conditions, but by methods evolutionary rather than revolutionary.

Transactions of the American Ceramic Society. Vol. XVI. Arthur S. Watts Editor. Published by the Society. Secretary's Office, Columbus, Ohio, 1914.

This annual carries, as usual, a fund of instructive material relating to clays and pottery. It chronicles also the proceedings of the meeting held at Wheeling, W. Va., February 24th, 25th, 26th and 27th of this year. To the papers read at the meeting are added supplemental essays on practical themes. There are comparisons between English and American glaze practice, hints on experimental enamel making, notes on the preparation of feldspar, and some fifty other discussions of varying interest and usefulness.

Steel Working and Tool Dressing. A Manual of Practical Information for Blacksmiths and All Other Workers in Steel and Iron. By Warren S. Casterlin. New York: M. T. Richardson Company, 1914. 8vo.; 207 pp.; illustrated. Price, $2.

This is a plain talk to his brother blacksmiths by the dean of the order. For it has taken fifty-seven years at the anvil for Mr. Casterlin to acquire the knowledge that he now disseminates. He has made a special study of cast steel, and sketches the process of its manufacture with enthusiasm and thoroughness. The young iron worker will find here helpful instructions simply conveyed.

Experiments. A Volume for All Who Are Interested in Progress. By Philip E. Edelman. Minneapolis, Minn.: Published by the Author, 1914. 8vo.; 256 pp.; illustrated. Price, cloth, $1.50; leather, $3.

A very attractive series of experiments, selected with a view to making the student acquainted with modern progress and the ways in which it has found itself, are presented here by the author. The first division of his work is devoted to simple grouped and graded experiments that include some of the most fascinating demonstrations in chemistry, electricity and mechanics. The second division takes up the principles of original research in science, invention and the industries. Plates, engravings and half tones in profusion brighten the work and are indeed indispensable to a ready understanding.

Second Course in Algebra. By William Benjamin Fite. New York: D. C. Heath & Co., 1914. 12mo.; 247 pp. Introduction price, 90 cents.

This book is planned to follow the author's First Course in Algebra which has received so much favor because of its scholarly and teachable qualities. It provides ample preparation for entrance to college and technical schools. It is written in the same spirit as the author's First Course but advantage has been taken of the fact that those who study it will be somewhat older and more mature than beginners of the subject. Complicated and artificial problems have been avoided. There is an abundance of material for drill and practice and for illustrating the applications of algebra to physics and geometry. The subject of ratio and proportion is treated in a chapter on fractions where it naturally belongs. The use of graphical methods which was begun in the First Course has been extended. The whole treatment is concrete and direct and represents the high water mark of mathematical text-book making.

A Study of Foods. By Ruth A. Wardall, M. A., and Edna Noble White, A. B. New York: Ginn & Co., 1914. 12mo.; 174 pp.; illustrated. Price, 70 cents net.

This text is designed neither for the finished cook nor the food expert. It is rather adapted to eighth grade or high school classes, while the laboratory exercises may readily be worked out in the home. The nature of raw materials and the effect upon them of heat and manipulation is set forth in a fundamental way. In view of present high prices, cost consideration is given the importance it deserves. The student is well drilled in the calculation of costs, both of raw material and of the perfected dishes. The various cuts of meat are fully illustrated and their uses and values clearly defined.

High-Power Gas Engines. By H. Dubbel. Translated from the German and Edited and Expanded so as to include British Engines and British Practice by F. Weinreb. New York: D. Van Nostrand Company, 1914. 4to.; 197 pp.; 423 illustrations and 13 folding plates. Price, $5 net.

The large gas engine, combining as it does the constructional features of the steam engine with the working cycle of the small internal combustion engine, is entitled to a separate literature and special consideration. Perhaps the most distinctive claim of the work in hand is based upon its many sectional drawings on a large scale. English firms have consistently refused to furnish the finer details of their practice, and to this reticence may be partly due, as the translator suggests, their failure to profit by the interchange of ideas as the Continental manufacturers have done. Since Mr. Dubbel's work deals only with the larger, double-acting type, while in England the tendency is toward multi-cylinder, single-acting systems—due, no doubt, to difficulties experienced with large cylinders—the translator has added to the original work much relating to modern British practice. His reference to some abandoned designs, with the reasons for their abandonment, should save considerable labor in wrong directions. Altogether the volume may be highly commended to inventors and manufacturers.

Motorcycles, Sidecars and Cyclecars. Their Construction, Management and Repair. By Victor W. Pagé, M.E. New York: Munn & Co., Inc. 550 pp.; 350 illustrations. Price, $1.50.

Those who have read Mr. Pagé's book on the automobile will welcome this volume on the motorcycle, in which he treats his subject with his usual thoroughness and clearness. Previously to this there has been nothing of a competent nature published in this country on the motorcycle, but in Mr. Pagé's book every detail of motorcycle construction is carefully explained, including power plants of both two and four cycle design, and various systems of carburetion, ignition and lubrication. Clutches, speed change gears, starting devices and brakes are fully covered and illustrated by numerous cuts of the best American and foreign machines; while for those who require technical information many useful tables and formulæ are given. Sidecars are fully covered, and a chapter is devoted to the cyclecar that is instructive. While the matter covered is mainly descriptive and explanatory, some space has been devoted to the practical questions of operation and maintenance. As a whole it is a useful book of reference, and by far the best of its kind yet published.

The Philosophy of Radio-Activity. Or Selective Involution. By Eugene Coleman Savidge. New York: William R. Jenkins Company, 1914. 8vo.; 151 pp.; illustrated. Price, $1.50 net.

In radio-activity we have an energy 250,000 times greater than any hitherto known. The author has made this energy the text for some able speculations upon the nature and properties of matter. His thought is always pregnant, and his expression vigorous even when it is most vague. With all due respect to the difficulties of the subject, there are many places in which the thought might have been more lucidly expounded. Still, a deep and stimulating work remains. Wherever the more familiar physiological processes are entered upon the touch is sure, the reasoning sound. The close analogy between radium emanation and recovery and the glandular process should throw light upon the latter and lead to important discoveries. We look forward with some eagerness to Dr. Savidge's forthcoming volumes on "The Cancer Problem" and "The Unclassified Diseases," to which the work in hand is a kind of preface.

Political Economy. By Charles Gide, Professor of Social Economics in the Faculty of Law in the University of Paris. Authorized Translation from the Third Edition (1913) of the *Cours d'Economie Politique*. New York: D. C. Heath & Co. 8vo.; 762 pp. Price, $3 net.

"Political Economy" is a term of rather forbidding aspect, but its dry reputation need deter no one from following with pleasure the intensely interesting exposition given us by Prof. Gide. From his early recognition of the invasion of natural law into the social world, to his closing sections on saving and expenditure, there is scarcely a dreary line in the work. Production, its factors and organization, receives premier consideration. Circulation and the monetary systems follow. The third book is devoted to distribution, and the fourth to consumption. All branches of the science are thus ably covered. The various schools of socialism, liberalism, and "solidarity" are clearly defined, and this feature alone, in consideration of the haze enveloping the average mind as to the tenets and aims of these antagonistic parties, makes the book worthy of popular perusal. It was written with the object of aiding French students in their Law Faculty examinations, and hence takes a distinctly French point of view, but the notes of this American edition cater especially to the student of our own land, and to both student and general reader the text may be heartily commended.

The Lumber Industry. Part IV. Conditions in Production and Wholesale Distribution including Wholesale Prices. Washington: Department of Commerce, Bureau of Corporations, 1914.

This report largely deals with the investigation authorized by the Senate and the House, and with the price-fixing combinations among manufacturers and wholesalers. The lumber associations and their activities are thoroughly canvassed, and the opinion arrived at seems to be that, while some purposes have been beneficial in aim both to producer and consumer, wholesale prices have been advanced by doubtful expedients and legislation has been shaped—or attempts been made to shape it—by aggressive lobbying and similar methods of persuasion or coercion. The report is a mine of information concerning production and distribution, with many charts covering from 10 to 17 years and indicating the movement of prices, the comparison of actual and list prices, and the fluctuations of different grades.

Texas Nature Observations and Reminiscences. By R. Menger, M.D. San Antonio, Tex.: Guessaz & Ferlet Company, 1913. 8vo.; 323 pp. Price, $2.

The present volume details private observations on Texas insect and animal life in general. Many of the illustrations are of great interest to naturalists.

We wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

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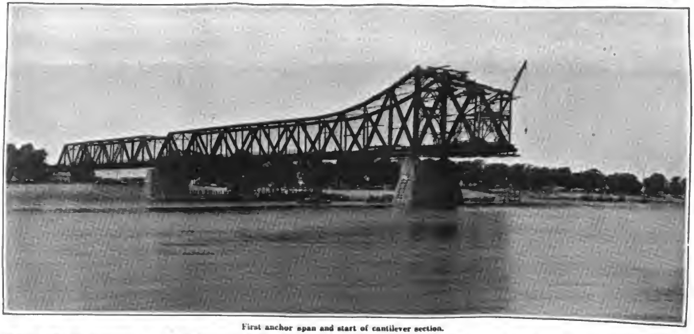

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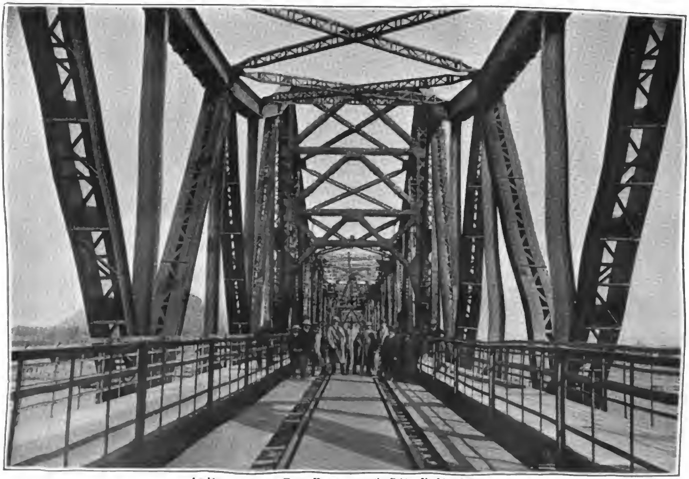

Looking through the Hoang Ho Bridge, on the Peking-Nanking Railway.

HOANG HO BRIDGE. A CONNECTING LINK BETWEEN THE CHINESE AND TRANS-SIBERIAN RAILWAYS.—[See page 308.]

How to Collect and Preserve Insects—II*

Methods and Apparatus Used in an Interesting Pastime

By Frank E. Lutz

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2027, Page 291, November 7, 1914

MOUNTING.

WE come now to the methods of mounting and preserving. The stock method is pinning. The almost universally adopted pin is 1½ inches long and has a very small head. It varies in thickness from extremely slender to as thick as an ordinary pin. The useful sizes are from No. 0 to No. 3. They are either plain "white" or enameled black. Much is to be said for both, with the voting probably in favor of black. At any rate, they should snap back when bent a reasonable amount. A pin that bends easily and stays bent produces profanity. Beetles are usually pinned through the right wing cover. All other insects, when pinned, are pinned through the thorax. In the case of flies it is well to pin a trifle to the right of the middle line, as the bristles on the back are important in taxonomy, and one side of the body at least should be perfect. True bugs should be pinned through the triangular portion of the thorax which is between the wings. See Fig. 7.

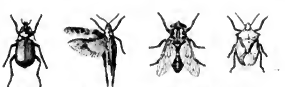

Fig. 7.—The black dots shaw where the pin should be inserted.

Very small insects are usually mounted on the tip of paper triangles, a medium sized insect pin being stuck through the broad end of the triangle. The triangles are of about as many sizes as there are collectors. A ticket punch can be purchased which has a die suitable for cutting these triangles. However, if they be cut with scissors or a sharp knife, such as a razor, a variety of sizes and shapes suited to different insects can easily be made. The best way is to cut tough, rather stiff paper into strips about three eighths of an inch wide and then snip off triangles from them by making transverse cuts. It is well to pin up a quantity of these triangles in odd moments and keep them on hand. When ready to mount, put a small bit of white shellac dissolved in alcohol or of some good elastic glue on the tip of a triangle and touch it to the underside of the thorax. Some difficulty will be experienced in keeping the insect straight on the point, especially if the adhesive be too thin. The triangles for ants should be fairly broad at the "point," and the front end of the abdomen, as well as the thorax, should be supported.

The method just mentioned is almost universally used for small beetles. Small flies and the like are frequently mounted on "minuten nadeln." These are short, very delicate, headless pins. Their use is illustrated in Fig. 8. Bits of pith, cork, or firm blotting paper (used edgewise) serve to connect the two pins. In the illustration the "nadel" is shown stuck through the insect and then into the support. A somewhat better plan is to arrange a number in advance by sticking the "nadel" through the support from below, leaving the point stick up, then mounting can be rapidly done by piercing the insects from below. It is well, in this case, to stop before the point comes entirely through the back, as then no pin shows, and furthermore, the characters on the back are not marred. "Minuten nadeln" have the advantage over glue on triangles that the glue does not always hold. On the other hand, the "nadel" cannot be used with many hard shelled beetles. Elbow pins (Fig. 8) are sometimes used, but are not very satisfactory as a rule. All mounts mentioned in this paragraph are usually put on the left side of the pin.

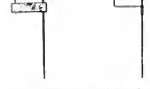

Fig. 8.—Pins for mounting small soft-bodied insects.

The height of the insects on the pin is important for the final appearance of the collection. A strip of cardboard whose width is one quarter to one third the length of the pin makes a convenient gage. With one edge held at the head of the pin, push the insect up until it touches the other edge. Or a block of wood containing a hole whose diameter is a trifle larger than that of the pin's head and whose depth is one quarter to one third the length of the pin may be used. Devices for regulating the height by sticking the point of the pin into a gage are not satisfactory because of the varying thickness of the specimens.

Mounting insects in balsam on glass slides will probably not be taken up by the general collector unless he be already accustomed to making balsam mounts. It is, however, the only satisfactory method of getting extremely small forms ready for study.

In collections, butterflies and moths usually have all four wings expanded to their utmost and more or less in line with the lateral axis of the creature's body. This makes a nice looking collection and is the best that can be done with most butterflies at least. However, many moths have natural rest positions which are not only interesting but economical of space. It is well therefore to expand the wings of the left side so that the markings on both front and hind wings show, but to leave the right wings in the natural rest position. The reason for expanding the left side rather than the right and for putting the triangles, etc. (see above) on the left side is that most people are right-handed. This arrangement makes it easy to use the pinning forceps with the right hand. Pinning forceps are strong forceps with broad roughened ends, and are useful in pushing the pins into the cork of the storage boxes. For the same reason when the wings of grasshoppers, wasps, etc., are spread it should always be the left wing.

The most common form of spreading board is illustrated in Fig. 9. The sides are made of soft wood. In the bottom of the central channel is a piece of soft cork. After pinning the insect, push the pin into this central cork until the back of the insect is nearly flush with the board. Then draw the wings to the desired positions by means of forceps or a fine needle caught in the strong front margin of the wings. Never use the fingers on moths and butterflies, as they will rub off the scales which cover the wings and give color to them. The wings may be held in position by means of fine pins or bits of heavy glass or strips of tracing cloth, held in place by pins placed outside of the wings. A combination of the last two methods, glass on paper, is best. It is well to have a number of boards with grooves of different widths for use with different sized insects.

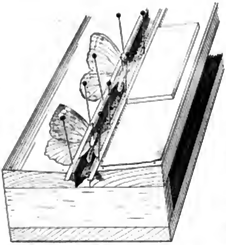

Fig. 9.—A common type of setting board showing different stages in "spreading."

Fig. 10 shows a setting board devised by Mr. Charles E. Sleight of Ramsey, N. J.—and perhaps by others—for spreading caddice flies and other insects when it is desired to have the legs spread as well. The holes running down the center are just large enough to accommodate that part of the pin which is above the insect. The wings are spread as before, except that now the under side is visible to the worker and the legs are accessible.

Flies (insects which have but one pair of wings), beetles (insects which have hard front wings), and bugs (insects which have the front part of the front wings leathery), are rarely spread, although they may be. The wings on at least one side of wasps should not be spread, as the way they fold them is of taxonomic value.

Should insects get dry and stiff before they are spread they must be relaxed. This is done by putting them in a covered jar or tin box containing water or moist blotting paper. A few drops of carbolic acid added to the water will prevent mould. Twenty-four hours will usually be sufficient to relax even the driest, but more time may sometimes be necessary. If the insect has neither scales nor hairs it can be quickly relaxed by immersing it in warm water.

It will be noticed that both of the setting boards illustrated here give the wings a slight upward tilt. If they keep this position it will not be objectionable, but they are not likely to do so, since the weight of the wings will probably drop them to the horizontal at least. Large insects dry more slowly than small ones, and it will probably be necessary to allow them to remain on the boards for about two weeks. They should certainly remain until thoroughly dried. No farther preservation is then necessary, as a rule, for the fairly hard bodied adult insects. Some tropical grasshoppers have large abdomens full of fat and decomposing food. They should first be opened by an incision along the belly, the viscera taken out, and the abdomen stuffed with cotton.

Caterpillars may be prepared in the following way: Make a circular incision at the hind end, cutting the intestine loose from the outer body wall. Then, laying the caterpillar on a piece of clean blotting paper, squeeze the viscera through this opening by gently rolling it with a lead pencil, beginning near the hind end and gradually working toward the front. After the viscera have been gotten rid of, for the most part, insert a straw and fasten the first segment of the larva to the end of the straw by means of a fine needle. Draw the hind segment up the straw until the larva is

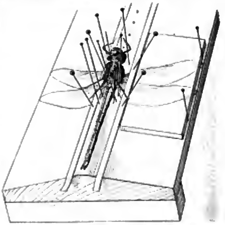

Fig. 10.—A setting board for use when it is desired to spread the legs.

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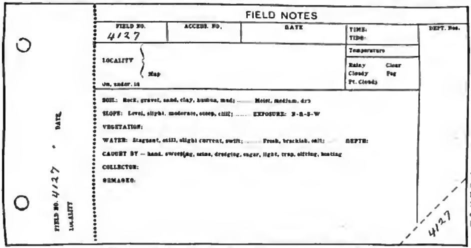
*Guide Leaflet No. 39, published by the American Museum of Natural History.

natural length and fasten it in the same manner. Then inflate the larva by gently blowing through the straw. Since the front end of the straw may get plugged up, it is well to make a small hole in the side of the straw before it is inserted. This hole had best come about midway between the larva's head and tail. Since inflation must be kept up until the larva's skin is dried, gentle heat is usually used. A tin can with holes punched in it for ventilation and heated by an alcohol lamp makes a good oven, or one made for the purpose can be purchased. Dealers also sell bellows, tubing, clips, etc., to make the work of inflating easier. At a recent meeting of the New York Entomological Society, Mr. Thomas Hallinan of Erie, Pa., exhibited caterpillars which had been filled with dry sand poured in through a funnel after evisceration. After drying, the sand can be poured out. However inflated, green larvæ are apt to lose their color, for it is chlorophyll, which fades rapidly. Slow drying paints relax the skin and distort it. Therefore, if painting is done, the pigments should be mixed with benzine or the like.

FIELD NOTES AND LABELS.

It is only by the greatest chance that the beginner gets a new or even rare species on ground that has been worked over by experienced collectors, but even the primary class in entomology may add to our store of knowledge if it keeps field notes well. Date of capture and locality are considered of prime importance. They should always be known and kept with every specimen, but the distribution and time of appearance of our more common species are known. It is of their habits that we are ignorant. What do they feed on? Under what conditions are they to be found when young and when old, day and night, winter and summer? What do they do, and how do they do it?

A sample field card is shown in Fig. 11. The "Remarks" are really the important part. In using this card the lower right hand number is torn off (after filling out the card *in the field*) and kept with the specimens to which the card refers until they are individually labeled. This is the card used in the American Museum. The stub is kept by the collector and the card is filed at the museum. Such a refinement of system is not necessary in most cases, but some system is imperative if your collection is to be worth while.



FIELD NOTES

FIELD NO. 4127

ACCESS. NO.

DATE

TIME:

TIDE:

DEPT. Nos.

LOCALITY

Map

On, under, in

Temperature

Rainy Clear

Cloudy Fog

Pt. Cloudy

SOIL: Rock, gravel, sand, clay, humus, mud; ...... Moist, medium, dry

SLOPE: Level, slight, moderate, steep, cliff; ...... EXPOSURE: N-E-S-W

VEGETATION:

WATER: Stagnant, still, slight current, swift; ...... Fresh, brackish, salt; ...... DEPTH:

CAUGHT BY — hand, sweeping, seine, dredging, sugar, light, trap, sifting, beating

COLLECTOR:

REMARKS:

FIELD NO. 4127

LOCALITY

DATE

4127

Fig. 11.—A field card such as is used at the American Museum.

The pin label should be small but legible. Certain firms make a business of printing these labels from small type, or the collector can make up a sheet by means of an ordinary typewriter (black ink is best) and have a block made from this greatly reduced in size. From this block any number of impressions can be made. Any printer will attend to the whole business. Dates should be filled in before cutting the labels apart. Field numbers can be written on the back of these labels or put on a separate label. The collector's name can also be put on a separate label. Similar labels should all be the same height on the pin throughout the collection.

STORAGE BOXES AND CARE OF COLLECTION.

Since certain members of a family of beetles (Dermestidæ) are given to eating dried insects, the storage boxes should have tight-fitting lids. Except for that, almost anything will do. Cigar boxes are not bad if carefully watched, but better boxes can be purchased at reasonable prices from dealers. Glass topped drawers are nice but not necessary. Whatever sort of box is used, the bottom, inside, should be covered with something which is soft enough to allow a pin to enter easily, but which will hold the pin when it is once in. The compressed cork of the dealers is best. Sliced cornstalk is used by some beginners, but two layers of the corrugated paper such as bottles are packed in is better than corn pith. The layers should be placed so that the corrugations run at right angles to each other.

In spite of precaution Dermestids may get in, although camphor balls or the flaked naphthalene will help to keep them out. If camphor balls are used, first heat the head of an ordinary pin, and while hot push the head into the ball. When cool, it will be solid, and the ball can be pinned into the box. If Dermestids do get in, they may be killed by pouring into the box about a teaspoonful of carbon bisulphide and closing the lid down tightly. Remember that the bisulphide is very inflammable.

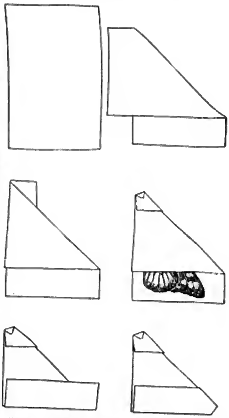


Fig. 12.—Method of packing a butterfly. The paper used in making the envelope should be stiff enough to protect the wings.

PACKING INSECTS IN THE FIELD.

It frequently happens that the collector cannot attend to his catch at once, or possibly for months. Of course those things which are collected in alcohol may remain there. Butterflies and the like should be put into triangular envelopes. The manner of making these is shown in Fig. 12. Never put more than one specimen in an envelope. Other insects can be packed between layers of cotton and cheesecloth, with naphthalene flakes put in to keep out ants, etc., or they can be put in sawdust. In the latter case it is well to sprinkle carbolic acid on the sawdust to prevent mould. An excellent method of packing insects (except butterflies and moths) which are to be dried, is to make tubes of unglazed paper around a lead pencil, first writing the data on that part of the paper which comes outside. One end is closed by folding in the paper there, and then the tube is nearly filled with freshly killed insects. Finally the other end is closed by folding in the paper. These tubes and the triangular envelopes can be packed in a cigar box, and if sprinkled with naphthalene to keep out ants and Dermestids will keep indefinitely. Never pack moist insects in a tin box and never close even a wooden box tightly if there are any moist insects in it. Mould will result if you do.

FINALLY.

Do not forget that information about the insects is usually of as much value as the specimen—or more.

A Course of Science Reading

By James Asher

In choosing books the users commonly select them without much regard to the suitability of the books for their needs and without much regard to their sequence in order of difficulty.

Because of lack of properly arranged courses of reading, much valuable time is not utilized in the best possible manner.

Having been deeply impressed by the lack of system pursued by many persons who are desirous of becoming well informed in science, the writer has carefully selected a list of books for readers of a general course in practically all the sciences.

The list of books below on the natural, physical, and mathematical sciences, is for the use of those who have at least a public school education or its equivalent.

The first place is given to the natural sciences, the second to the physical, and the third to the mathematical sciences. In the list of natural sciences the first place is given to hygiene, because it treats of the life and health of man. In the list of physical sciences the first place is given to physics, which was formerly called natural philosophy. According to Francis Bacon, this is the great mother of all the sciences. The first place in the list of mathematical sciences is given to arithmetic, which is always the first to be studied in a mathematical course, and which is by far the most useful of the mathematical sciences.

For one who cannot afford a college education, the steady pursuit of the course here given should be a good substitute. It may, with advantage, extend throughout four years, which is usually the time required in securing a college education.

A man, after having successfully pursued this course for four years, would almost certainly be imbued with the scientific spirit; that is to say, the spirit of care and accuracy. He would almost certainly have increased mental power, a broad culture, and a fund of knowledge and power which should be of benefit to him in any walk of life.

The list is as follows:

"A Manual of Personal Hygiene." W. L. Pyle.
"Lessons in Elementary Physiology." T. H. Huxley.
"American Natural History." W. T. Hornaday.
"The Elements of Botany." A. Gray.
"New Physical Geography." R. S. Tarr.
"First Book in Geology." N. S. Shaler.
"Textbook of Mineralogy." E. S. Dana.
"Elements of Physics." A. P. Gage.
"Inorganic Chemistry." I. Remsen.
"Astronomy for Everybody." S. Newcomb.
"Descriptive Meteorology." W. L. Moore.
"Advanced Arithmetic." G. A. Wentworth.
"Mensuration for Beginners." I. Todhunter.
"Complete Algebra." G. A. Wentworth.
"Plane and Solid Geometry." G. A. Wentworth.
"Plane and Spherical Trigonometry, with their Application to Mensuration, Surveying, and Navigation." E. Loomis.

The Principle of Similitude

In an article in *Physics*, Rev. R. C. Tolman brings forward some arguments that seem to hold good throughout the field of physical science.

The fundamental entities out of which the universe is constructed are of such a nature that from them a minute universe could be constructed, exactly similar to the present universe. This is called the principle of similitude. This fundamental postulate is a relative principle; that is, the principle of relative size. In Mr. Tolman's paper it is shown that relations must hold between the changes of lengths, masses, time intervals, energy quantities, etc., in order to construct the miniature world in question.

The Hoang Ho Bridge

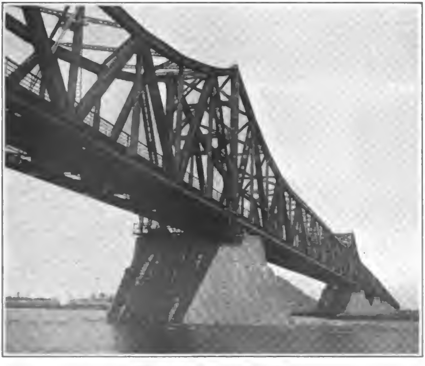
An Important Link in Railroad Communication in the Far East

An interesting bridge has recently been completed across the Hoang Ho, or Yellow River, in China, by the Maschinenfabrik Augsburg Nurnberg Ag, which is of special importance because it forms the connecting link between Peking and Nanking, and establishes direct communication between these two cities and the Trans-Siberian Railway, thus making it a notable feature in the advancement of rail communication of the world. Great care was required both in the designing and the erection of this bridge on account of the uncertain nature of the Yellow River, which is frequently subject to flood conditions, and the water rises several meters within a few hours.

This bridge, which is the largest stone pier bridge in China, is about 4,120 feet in total length, and the portion over the main bed of the river is on the cantilever principle, with a central span of about 540 feet, on either side of which is an anchor span of about 421 feet. There are also nine truss spans, each of about 304 feet, eight at one side of the river and one at the other, which carry the line over the bottom land that is flooded at low water. The spans rest on piers of reinforced concrete and stone, but as no solid rock foundations could be found, the piers were built on reinforced concrete piles which were driven at an angle to give a spreading base. For the central river pier a compressed air caisson had to be used on account of the great depth of the soft and unreliable material of the river bed.

At present only one line of track has been laid across the new bridge, with a footway on either side; but this is only considered a temporary arrangement, for it will be a simple matter, when increasing traffic demands it, to remove the footways to outside brackets and to lay a second track, and this is the final arrangement contemplated in the original plans.

Inside the caisson of the central pier.



Main channel pier and cantilever span.

The accompanying illustrations give a good idea of the character and details of the bridge, and it will be seen that it is a very substantial and symmetrical structure that can be seen rising from the plain a long time before it is reached. Its cost was 4,504,358 kooping taels, or roughly, about $2,800,000.

Leadless Glazes on White-Ware

The possibility of devising a glaze for white-ware that does not contain lead in any form has been studied by the U. S. Bureau of Standards, and the experiments and conclusions of E. T. Montgomery, assistant ceramic chemist, are told in one of the recently issued Technological Papers issued by the Department of Commerce, from which the following facts are derived:

The glazes used on white-ware are composed of borosilicates of the alkalies, lime, lead, and alumina, which are applied to a body previously fired to the desired maturing point approaching vitrification more or less closely. The same type of glaze is also employed with American porcelain and the English bone china as distinguished from the Austrian, French, and German products where, because of the low biscuit and high glost firing temperature, it is possible to use leadless glazes.

The use of lead oxide, commonly introduced as the carbonate, has given rise to a wide-spread agitation concerning the poisonous nature of the compound and its deleterious influence upon the health of the workmen under conditions permitting careless operation and neglect of ordinary sanitary precautions. A study of American white-ware potteries shows, however, that such conditions as have been described as existing in European works do not prevail and that in reality the ill effects due to plumbism are very slight in extent. It cannot be denied that there is a potential danger, but the enforcement of rules concerning ordinary cleanliness and ventilation suffices to prevent lead poisoning.

An extensive series of experiments were made with a number of glazes that contained no lead, accompanying a thorough investigation of all phases of the subject, with the result, in the opinion of the investigator, that it would be very premature at the present time to say that we can make a leadless glaze for white-ware, china, or porcelain that could be substituted for the present lead glazes. Both have special faults and special virtues, but for use under general factory conditions, make them as perfect as we can, we are not likely to find any element, compound, or combination of compounds which will exactly duplicate the many excellent properties of lead as a glaze ingredient.

Direct Determination of Rubber by Combustion Method

A method that can be employed quite satisfactorily has been developed by L. G. Wesson, of the U. S. Bureau of Standards. It is described in No. 35 of the Technological Papers published by the Department of Commerce as follows:

The procedure, in brief, consists first in forming the nitrosite of rubber by the action of nitrogen trioxide gas upon a finely ground and acetone-extracted sample of the rubber suspended in chloroform. The insoluble nitrosite, fillers, etc., are then filtered out and the nitrosite dissolved in acetone. The suspension of finely divided mineral matter is then allowed to settle out, or is thrown down with the centrifuge. An aliquot portion of the solution is transferred with a pipette to a small flask, and its volume reduced by evaporation to a few cubic centimeters. This small volume of acetone solution of the nitrosite is now transferred with the help of ethyl acetate to a porcelain boat containing alundum, and, after the acetone and ethyl acetate have been expelled by warming the boat for several hours in a drying oven, the nitrosite is burned in a current of oxygen and the carbon dioxide thus formed is absorbed in soda-lime and weighed. If all of the carbon originally in the sample as rubber, and only such carbon, reaches the soda-lime apparatus as carbon dioxide through the intermediate nitrosite, the equation $C_{10}H_{16} = 10CO_2$ enables one to calculate the $C_{10}H_{16}$ or real caoutchouc content of the sample.

The results indicate a fair degree of reliability for both raw rubber and high-grade vulcanized compounds. The use of this method for the analysis of low-grade compounds and for the simultaneous determination of sulphur of vulcanization may be possible with further study.

Difference of Longitude Determined Photographically

By a method described by G. Lippmann in *Comptes Rendus* it is possible to obtain a photographic record of the difference of longitude between two stations without any transit instrument or personal observation error. A telescope is arranged to photograph a small region of the zenith at each station. Into each of these a collimator is adjusted so as to project the image of a small illuminated slit on the plate showing the star images, the beam of light from the collimator being adjusted to exact verticality by a mercury surface. By these means the artificial images are impressed simultaneously on the star plates at the two stations by employing electric sparks operated by a mechanical device to discharge exactly in unison with the receipt of a wireless signal from some central station such as the Eiffel Tower. The difference in right ascension of the two artificial marks on the photographs is then obtained from a knowledge of the star positions from standard catalogues. By taking a series of exposures on each plate the accuracy of the result can be appreciably increased.

A New Apparatus for the Direct Measurement of Radioactivity*

Of Value in Both Chemical and Electrical Investigations

MEASUREMENTS of radioactivity constitute an exceedingly sensitive method of chemical analysis by which it is possible to measure quantities of radioactive substances too small to be detected by the spectroscope. This result is due partly to the extraordinary properties of the radioactive elements, and partly to the sensitiveness of certain electrical instruments, which were in use before the discovery of radioactivity, and which have greatly facilitated its study. The most important of these instruments are the gold leaf electroscope and the quadrant electrometer. The sensitiveness of the former resides chiefly in the lightness of the moving parts, that of the latter in the ingenuity and delicacy of its construction. These sensitive but fragile instruments are suitable only for the use of expert physicists who are able to convert their readings into absolute measurements by means of rather complex methods of comparison and calculation. The deflections of the gold leaf electroscope are read with the aid of a microscope having a micrometer eyepiece; those of the quadrant electrometer are indicated by a spot of light moving on a transparent scale.

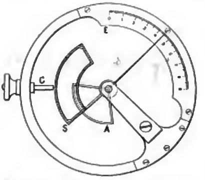


Fig. 1.—Plan of Szilard apparatus for direct measurement of radioactivity.

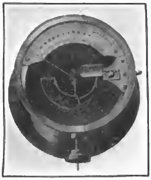


Fig. 3.—View of complete apparatus.

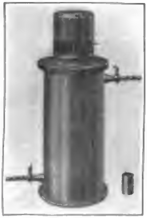


Fig. 6.—The apparatus combined with gas condenser for measuring emanations from mineral waters.

My object was to construct an apparatus which would measure radioactivity as directly as the amperemeter measures current strength, and by the same means (a graduated scale and a rigid needle). This problem appears difficult when we remember that the forces called into play in radioactive measurements are a thousand million times smaller than those which are employed in a milli-amperemeter, and that those forces are derived, not from a material substance, but from an independent electric charge which is communicated to the apparatus and which is liberated by the conductivity conferred upon the air by radioactive agents.

For these reasons I constructed an apparatus in which the weight of the moving parts is reduced to the minimum, and the rotary displacement caused by minute electrical variations is as great as possible.

The construction of the apparatus is indicated in Figs. 1 and 2. The needle *A* is formed of a narrow ribbon of sheet metal and comprises two rigidly connected parts: a long pointer and a hollow circular sector. It is attached to a very short axis *X*, which turns on ruby bearings. This axis is attached to the lower end of a helical spring *R*, the upper end of which is fastened to the bridge *P'*. The spring serves both to suspend the needle and to oppose its rotation.

An insulated rod *C*, sliding through the wall of the case, allows an electric charge to be communicated to the fixed double sector *S*, into which the sector of the needle *A* is drawn to an extent proportional to the charge, causing the pointer to move over the scale *E*.

In order to attain the desired result it was necessary to impose upon the dimensions and weight of the parts limits that taxed the skill and patience of expert watchmakers. The needle is about 2 inches long, 1/1,250 inch thick, and weighs 1/7 grain. It was cut from one sheet of tempered steel. The axis, of the same material, weighs 1/65 grain. The suspending spring is made of a ribbon of steel 1/2,500 inch thick.

The fixed sector *S*, the only part that carries an electric charge, is insulated by the amber plate *I*, through which the support of the sector extends into the lower chamber, which contains the radioactive substance. The needle is always connected to earth through the suspending spring, so that it is never charged. This is a very important detail. It allows the scale to be placed very near the needle and gives certainty to the operation of the instrument. A charged needle would adhere to the scale and make measurement impossible.

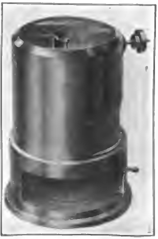


Fig. 5.—Apparatus combined with a special condenser for the measurement of large quantities of radioactive substances.

In the use of the apparatus a small charge is first communicated to the fixed sector *S* by means of the insulated rod *C*, which is pushed inward until it almost touches the sector. The charge attracts the sector of the needle *A*, causing the needle to turn on its axis. A charge obtained by rubbing a piece of sealing wax or an ebonite penholder is sufficient to produce the maximum deflection of 90 degrees. The needle remains in this position as long as the fixed sector retains its charge. The apparatus may be shaken and the needle may be touched with the hand without altering the deflection. A charged instrument was carried from Paris to Berlin without losing its charge.

When a radioactive substance is placed in the lower compartment the air is gradually ionized, the fixed sector *S* is gradually discharged, and the needle, impelled by the spring, returns at a uniform rate toward the zero mark. If the radioactive substance is removed the movement of the needle instantly ceases.

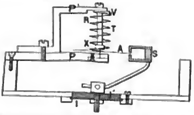


Fig. 2.—Vertical section through the apparatus.

The movement is very easily observed. For example, a small quantity of the feebly radioactive oxide of uranium causes the needle to move about one fourth as quickly as the pointer of a stop-watch. The apparatus possesses another great advantage in its fixed and correct scale, which allows direct measurements to be made. The scales of ordinary electroscopes and electrometers are movable and arbitrary, so that each measurement necessarily involves a comparison with a standard radioactive substance. In the new apparatus, the security of the mounting and the constancy of the opposing force of the spring make it possible to standardize the scale once for all.

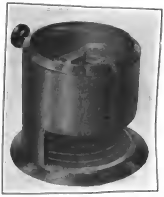


Fig. 4.—Szilard apparatus for direct measurement of radioactivity.

I use a scale based on the radioactivity of the black oxide of uranium, U_3O_8. A surface of 25 square centimeters (about 4 square inches) covered with a layer

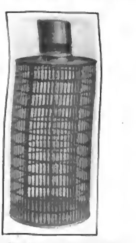


Fig. 7.—Interior of the gas condenser.

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* Translated from H. Szilard's article *La Nature*.

of this oxide of suitable thickness (increase in thickness beyond a certain limit produces little change in radioactivity) causes the needle to move over one scale division per second. The radioactivity of any other substances is measured by placing the substance in the apparatus and counting the number of seconds, as given by a seconds' clock, occupied by the needle in traversing a given number of scale divisions. The number of divisions divided by the number of seconds expresses the radioactivity of the substance directly in uranium units. An equivalent method consists in counting the number of scale divisions which the needle crosses in 100 seconds.

Boltwood has found that of the total radioactivity of uraniferous minerals about 20 per cent is due to uranium, 60 per cent to radium and its derivatives, 10 per cent to ionium, and the remainder to actinium and other elements. It is known, also that a mineral which exhibits (in a thick layer) a radioactivity of one uranium unit contains from 20 to 30 per cent of U_3O_8, and about one part of radium to each 3,000,000 parts of uranium. With the aid of these data a nearly complete analysis of the radioactive ingredients of a mineral can be made by one measurement, effected in less than one minute. Minerals containing thorium can be analyzed in the same way. The same method is applicable to all solid radioactive substances, natural or artificial, such as the mud and residues of hot springs, pharmaceutical products, etc.

For the direct determination of larger quantities of radium (0.1 to 100 milligrammes) the apparatus is attached to a special condenser (Fig. 5), which allows only the gamma rays to pass into the ionizing chamber. For this purpose the scale is so constructed that a displacement of one division per second corresponds to one milligramme of pure radium. The uranium scale may be employed, however, if the ratio between the two units has been determined for the apparatus.

For the measurement of radioactive emanations of mineral waters, and other substances, solid, liquid, or gaseous, the apparatus is combined with a gas condenser (Figs. 6 and 7). In this way it is possible to detect the radioactivity of one ten-millionth of a milligramme of radium, which is the average radium content of 100 grammes (about 3 ounces) of granite.

The apparatus may be employed as an electrometer in researches which have nothing to do with radioactivity. Its sensitiveness is indicated by the facts that its capacity is 2 electrostatic units and a current of 10^{-11} amperes causes the needle to move at the rate of ½ degree per second. Hence the apparatus is well adapted for the measurement of atmospheric potential, the electric charge of rain drops, and the ionization of the atmosphere.

Radium Therapy

Notes on Results Obtained at the London Radium Institute

The report of the London Radium Institute for 1913 shows that a great variety of cases were treated, and, as the Institute makes it a rule not to treat cases of malignant diseases that are operable under ordinary circumstances, the greater part of its work is necessarily in the nature of a last resort. It is therefore a matter of great interest to note the unexpected number of such cases that are classed as apparently cured. Of course such a result can only be positively claimed after the lapse of a long period of time, probably several years, when it can be definitely shown that no new manifestations of the original disease have appeared; still, with the short period for observation that has yet been possible the indications in a very satisfactory percentage of the cases treated have been of an encouraging nature.

The following notes constitute a brief summary of the cases included in the report of the Institute, which is a valuable contribution to the literature of radium therapy.

The results obtained in the treatment of epitheliomata affecting glabrous surfaces call for no fresh comment, and in suitable instances removal of the growth by radium may be confidently anticipated.

Epitheliomata of the buccal, lingual and pharyngeal mucous membranes still prove both refractory and disappointing in their response to radium, but a new method of treatment has recently been devised which in instances of cancer of the tongue has given distinctly encouraging results.

Several cases of epithelioma of the oesophagus have been under treatment, but unfortunately the majority of these have been in so advanced a stage as to preclude all hope of success. In those instances however where complete occlusion had not occurred, and it was possible to introduce radium actually into the lumen of the growth, distinct though temporary benefit has resulted; and that this effect is not merely mechanical, due to the dilation of the stricture by the apparatus, is evidenced by the fact that the improvement in the power of swallowing has persisted for six or even nine months after the termination of the treatment.

Carcinoma of the uterus still continues to yield most gratifying results, and the effects of radium treatment in inoperable cases are far in advance of those obtained by any other known medical or surgical methods. The local manifestations of the disease are benefited in the most striking fashion, and the complete disappearance of fungating growth, arrest of hemorrhage and discharge, healing of ulcerations and relief from pain are phenomena of almost daily occurrence. In favorable cases, moreover, the treatment appears to exert a distinctly retarding influence on the dissemination of metastatic deposits, and thus to arrest the progress of the disease. It is not possible, however, to speak of "cure" even in these latter instances.

Great care must be exercised in the treatment of recurrences, which make their appearance within six months of the performance of a Wertheim's operation. The functions of the trophic nerves of the pelvis seem often to be seriously impaired by the extensive and elaborate dissection which is associated with this method of hysterectomy.

In cases of carcinoma of the breast many patients exhibit a great susceptibility to radium; the primary growth becomes smaller, infected glands and subcutaneous nodules lessen or perhaps even disappear. Little or no effect appears to be exerted in the prevention of metastatic deposits, though the treatment does not, at any rate, hasten their dissemination. Some cases in which pleurisy, dependent upon carcinomatous invasion of the pleura, had been present have shown remarkable improvement.

A few patients have been under treatment at intervals of three or four months since the opening of the Institute in September, 1911, and it has been noted that a stage in their treatment is reached sooner or later at which the response to radium fails, and the benefit derived becomes negligible.

Encouraging results have been obtained in the few instances of carcinoma of the thyroid that have come under notice, the progress of the disease has been arrested, and a decrease in the size of the existing growth has been obtained, the general discomfort and dysphagia when present being greatly relieved.

The superficial lesion in Paget's disease is usually speedily cured by one hour's exposure to a half strength plate unscreened, but the underlying induration and affection of glands, if present, require prolonged treatment with heavily screened applicators if any real benefit is to be obtained; in cases in which the patient is willing to submit to operation this procedure should always be adopted.

Carcinoma of the rectum displays much variation in its response to radium therapy, and numerous factors have to be considered in prognosis. Speaking generally, the soft annular and vascular type of growth is much more favorably affected than the flat, hard, non-annular plaque with much subjacent induration. In the treatment of this latter class of growth the action of the gamma rays (which it is impossible to prevent) on the healthy rectal mucous membrane opposite the plaque produces a proctitis, which though generally transient, sometimes proves both persistent and severe, and adds greatly to the patient's discomfort. In the treatment of the former type, if the radium tube be of proper dimensions and introduced accurately within the lumen of the growth, little or no healthy mucous membrane is affected by the gamma rays, and no proctitis occurs.

Growths situated in the upper half of the rectum appear to be more amenable to treatment than those in the lower, though this may be due to the fact that tenesmus is always more constant and severe when the growth is near the sphincters.

The number of cases of carcinoma of the prostate which have been treated up to the present is not very large, but benefit has been noted in all of them. Haematuria, when existent, has been either diminished or abolished, pain has been greatly lessened, and the size of the growth decreased.

Nine cases of carcinoma of the bladder have been treated, and in six instances the results have been most gratifying. The haematuria, cystitis, and all subjective symptoms have disappeared, and cystoscopic examination has shown that the size of the growth has been greatly lessened, and any ulcerated surface has become covered with healthy epithelium.

But little has been added to our knowledge of the treatment of rodent ulcer, but when dealing with the question of prognosis it appears justifiable to divide rodent ulcers into two definite clinical types.

1. The hypertrophic nodular type, with slight superficial ulceration of a scaly character. This class responds extremely well to radium, and yields most satisfactory results.

2. The excavating type, with undermined and overhanging edges and a gelatinous base. This not infrequently proves very intractable, and repair is most difficult to effect.

Rodent ulcers attacking cartilage, bone or mucous membranes are very refractory, though an exception should be made with regard to the orbital mucosa, which is generally very amenable to the action of radium.

Speaking in general terms sarcomata, if taken in their early stages, and before dissemination has occurred, do very well under radium treatment.

The best results are obtained in sarcomata of the tonsil and postnasal space, and the results in many such cases are amazing, the growths completely disappearing withni six weeks of the treatment. Lymphosarcomata also give excellent results. Melanotic sarcomata are not influenced by radium, and in the few cases that have been treated no benefit has been observed.

In lymphadenoma when the disease is localized and confined to one or more small superficial areas the disappearance of the enlarged glands is frequently brought about by the use of radium, and the progress of the disease is thus arrested.

When, however, the condition is generalized, the employment of numerous large and powerful applicators becomes necessary, and this heavy dosage is almost always followed by severe systemic disturbance, with high temperature and general malaise. After the reaction has subsided considerable improvement is often apparent, but this is only temporary in character, and the condition sooner or later returns with increased severity.

In almost every instance of mediastinal tumors that have come under observation the rate of growth has been very markedly checked by the use of radium, and in one or two cases a definite decrease in the size of the tumor, as seen by X-ray screening, has undoubtedly occurred.

If the condition be accompanied by an accumulation of fluid in the pleura and paracentesis be performed, radium appears to exert a very remarkable action in lessening the tendency of the production of further effusion.

In fibroid diseases of the uterus radium exerts a most beneficial action upon the distressing symptoms, menorrhagia and metrorrhagia, which are the almost invariable concomitants of this condition, though it seldom produces any very great diminution in the size of the uterus.

Leucoplakia patches on the tongue, cheek, or vulva are speedily removed by radium, but they tend to recur sooner or later.

Before expressing an opinion as to the possibility of radium treatment effecting an improvement in any particular instance of flat superficial naevi, capillary naevi "port wine stains," etc., it is advisable to subject the lesion to diascopy. If blanching is readily effected by gentle pressure, the result of the treatment will probably be satisfactory; but if it be found impossible to produce blanching except by great pressure, it is unlikely that radium can do much for the condition.

Infinite patience is necessary in the treatment of superficial naevi, and the utmost caution must be observed.

Cavernous naevi do excellently under radium, especially when of such shape that "cross fire" radiation is possible.

Warts and papillomata yield readily to short exposures of from twenty minutes to one hour's duration with half strength apparatus unscreened. The reaction is but slight and the resultant scar scarcely noticeable.

Tuberculosis of Glands.—In cases in which surgical measures have been declined for cosmetic reasons, radium often proves of considerable value, either when used alone or as an adjunct to vaccine treatment.

Lupus Vulgaris.—As a routine treatment for this disease Finsen light is greatly to be preferred to radium, but where it fails to effect a cure or improvement radium sometimes proves of great use.

In spring catarrh the employment of radium is strongly to be advocated, as it will often cure the most intractable cases. Personal idiosyncrasy is, however, a very important consideration, and it is essential to proceed with great caution, giving short unscreened exposures at intervals of a fortnight, and carefully noting the reaction.

Keloids give most excellent results when treated with radium, and a general improvement if not complete cure can be safely predicted. In tender and painful keloids the anaesthetic effect of radium is generally very marked, and appears very early in the treatment.

In the case of Lupus Erythematosus, it has been found that this decidedly intractable and puzzling disease often responds favorably to radium, even after all routine methods have failed.

Psoriasis and Chronic Eczema.—Both of these conditions generally yield readily to short unscreened exposures of from two to five minutes' duration, given on three successive days, the series of exposures being repeated at intervals of a fortnight. The patches quickly disappear after a slight superficial reaction, and in eczematous cases there is but little tendency to recurrence. With psoriasis, however, the disease almost invariably reappears after a time, though with some patients the interval that elapses may be of many months' duration.

Lichenification of the skin, with its attendant intolerable itching, is quickly relieved and often completely cured by one exposure of ten or fifteen minutes' duration to a half strength applicator screened with 0.01 millimeter of aluminium.

Pruritus.—The analgesic effect of radium is often of the greatest use in this disease, and short unscreened exposures frequently produce a degree of relief which is unattainable by any other measure. This is especially noticeable if the pruritus occur in association with a definite lesion such as leucoplakia or hyperkeratosis.

Few patients suffering from exophthalmic goiter have as yet been treated at the Institute, but the results obtained are sufficient to justify a trial of radium when other treatments have failed to produce any result.

Arthritis Deformans.—The daily administration of 250 cubic centimeters of radium emanation solution of a strength of not less than 1 millicurie per liter to patients suffering from this obstinate and painful disease is sometimes attended by very remarkable results. It is difficult to predict with certainty the degree of improvement likely to occur in any particular instance, but the cases which appear to derive most benefit are those in which the disease is of relatively short duration, and the changes are periarticular in type and multiarticular in distribution. The age of the patient also exerts some influence, those under 40 responding more quickly to the action of the emanation. Cases with a definite gouty history sometimes experience an acute exacerbation of all their symptoms within the first week or ten days of their treatment, but this disturbance is quite transient, and is usually followed by a distinct change for the better.

Little or no improvement can be looked for in instances where cartilaginous or osseous changes are predominant, and the radium emanation solution is powerless to bring about the absorption of osteophytic growths or the loosening of fibrous or bony ankylosis.

When limitation of movement is due to periarticular fibrous thickening considerable increase of mobility often follows on the taking of the radium water and enables patients to perform actions, such as feeding themselves, brushing their hair, shaving, etc., which they may have been powerless to do for some months or even years.

Other favorable effects of the treatment are the lessening or disappearance of the muscular and articular pains, the grating of the joints on movement is not so marked, the muscles regain much of their lost tone, and the patient's general health is much improved. This is especially noticeable when the patients are suffering from anaemia, the haemoglobin index being rapidly increased.

Much research work has yet to be undertaken to enable an accurate opinion to be formed of the manner in which radium emanation solution produces these results, as its action appears to be a multiple and highly complex one, but the reinforcing of the body ferments, the increase of tissue oxidation, and the dissolving uric acid are undoubtedly factors which contribute to its success.

TABULATED REPORT OF THE LONDON RADIUM INSTITUTE.

	Examined but not Treated.	Results Not Yet Noted	Prophylactic Treatment Only	Apparently Cured	Cured	Improved	Not Improved	Abandoned Treatment	Dead	Total
Adenoma of thyroid	1	2	..	..	..	..	..	..	..	3
Fibromata	3	..	..	..	1	2	2	1	..	10
Fibroid disease of uterus	..	1	..	..	..	6	..	..	..	7
Leucoplakia	3	..	..	1	..	2	..	..	..	6
Naevi										
Capillary	..	4	..	..	1	19	1	..	..	25
Cavernous	1	1	..	..	2	8	2	..	..	14
Moles, warts and papillomata	1	2	..	..	8	6	1	..	..	18
Tuberculosis										
Glands	..	..	..	1	..	2	..	..	..	3
Skin	1	..	..	..	..	5	..	..	..	6
Conjunctiva	1	..	..	..	..	..	..	..	..	1
Spring Catarrh	..	..	..	1	..	1	..	..	..	2
Chronic inflammations	1	1	..	..	2	3	..	..	..	7
Chronic ulcerations	1	..	..	..	1	6	1	..	..	9
SKIN DISEASES—										
Keloid and vicious cicatrices	2	2	..	2	..	10	1	..	..	17
Lupus erythematosus	..	..	..	..	..	6	..	..	..	6
Psoriasis	..	1	..	..	..	4	2	..	..	7
Pruritus	..	2	..	..	2	2	2	..	..	8
Chronic eczema	..	..	..	..	..	3	1	..	..	4
Lichenification of skin	..	..	..	..	..	1	..	..	..	1
Mycosis fungoides	..	..	..	..	..	1	..	..	..	1
Roentgen-ray dermatitis	..	..	..	..	..	..	1	..	..	1
Telangiectasis	..	..	..	..	..	1	..	..	..	1
Hypertrichosis	..	..	..	..	..	..	1	..	..	1
GENERAL DISEASES—										
Arterio-sclerosis	3	1	..	..	..	2	1	1	..	8
Exophthalmic goitre	1	1	..	..	..	4	..	..	..	6
Myelogenous leukaemia	..	..	..	..	..	1	..	..	..	1
Myasthenia gravis	..	..	..	..	..	..	1	..	..	1
Neurasthenia	1	..	..	..	..	2	..	3	..	6
Neuritis	6	5	..	..	..	5	3	..	..	19
Gout	..	2	..	..	..	3	..	2	..	7
Neuralgias	..	2	..	1	..	2	1	..	..	6
Rheumatism	3	2	..	..	..	1	..	3	..	9
Arthritis deformans	41	69	..	..	..	47	39	8	..	204
Totals	112	176	30	56	18	341	152	50	37	972

	Examined but not Treated.	Results Not Yet Noted	Prophylactic Treatment Only	Apparently Cured	Cured	Improved	Not Improved	Abandoned Treatment	Dead	Total
CARCINOMA, Squamous-celled.										
Glabrous skin	1	..	1	2	..	4	4	1	..	13
Buccal, oral, lingual and pharyngeal mucous membranes	6	10	6	..	..	9	25	2	4	62
Oesophagus	5	..	..	..	..	4	4	1	..	14
Larynx	1	2	..	..	..	1	..	..	..	4
Vagina and vulva	..	..	1	1	..	3	1	1	1	8
Uterus	..	2	2	..	..	27	8	1	2	42
Penis	..	..	..	..	..	..	1	..	..	1
Bladder	..	..	..	3	..	3	..	1	2	9
Carcinoma, spheroidal celled										
Breast	11	22	11	2	..	40	19	11	12	128
Liver and gall bladder	..	..	..	..	..	1	..	..	..	1
Thyroid	..	..	..	..	..	3	..	..	1	4
Paget's disease	..	..	..	1	..	..	..	..	..	1
Carcinoma columnar-celled—										
Large intestine	1	4	2	..	..	..	..	1	1	9
Rectum	9	9	1	..	..	23	16	..	6	64
Stomach	..	..	..	..	..	1	1	1	..	3
Ovary	..	2	..	..	..	..	1	..	2	5
Prostate	1	..	..	..	..	4	..	..	..	5
Kidney and suprarenal gland	..	1	..	..	..	..	..	1	..	2
Parotid	..	..	..	..	..	..	1	..	..	1
Rodent Ulcer	4	21	2	40	..	34	7	3	..	111
SARCOMATA										
Spindle-celled	1	..	1	1	..	8	4	1	1	17
Round-celled	1	..	..	..	..	1	..	..	1	3
Melanotic	..	..	1	..	..	..	1	..	..	2
Myelosarcoma	1	..	..	..	..	1	..	..	..	2
Lymphosarcoma	..	1	..	..	..	2	..	..	..	3
Endothelioma	..	2	2	..	..	2	2	1	1	10
Lymphadenoma	..	..	..	..	..	4	2	1	..	7
Malignant glands	1	1	..	..	..	..	2	3	2	13
Parotid tumour	..	..	..	..	..	..	1	..	..	1
Abdominal tumour	..	..	..	..	..	..	1	..	1	2
Mediastinal tumour	..	1	..	..	..	4	..	1	..	6
Villous tumour of bladder	..	..	..	..	..	2	1	..	..	3
Polypi of vagina	..	..	..	..	1	..	..	..	..	1

Protecting Canal Bottoms Against the Erosions Caused by the Use of Screw-Propelled Vessels

By Our Berlin Correspondent.

It is a fact of common knowledge that the bottom of a canal is affected in a high degree by screw-tug operation. In the center there is considerable erosion, the washed-out sand forming on both sides obstructions which must be removed by costly dredging, in order to restore the profile of the canal.

As regards the cause to which canal erosion is due, there is at present general agreement that the phenomenon is mainly to be ascribed to the joint effect of the propeller screw and rudder. The screw draws in the water peripherally in a forward direction, and after accelerating it, allows it to flow off backward, in a motion at first cylindrical, and afterward divergent (spiral), comprising a rotating and an axial component.

Tests made by Dr. Gebers for the Prussian Department of Public Work have brought out the prominent part played in this connection by the rudder. A rudder arranged behind the propeller screw was found to deflect part of the rotating water downward, i. e., toward the canal bottom, thus producing erosion. He therefore suggested that this effect should be prevented by providing, to the right and left, respectively, of the propeller screw, two rudders reaching only as far as the boss of the screw in a downward direction and thus eliminating any deflection of the rotating water particles.

In accordance with this suggestion, the Prussian government has ordered all canal steamers to be fitted with twin rudders, though this arrangement affords a partial protection only as long as the rudder is held accurately amidships. In fact, as soon as the rudder is turned, thus entering the flow around the screw, there is a considerable erosion of the canal bottom, and since the rudder is intended for use in steering, the benefit to be derived from Dr. Gebers's scheme is quite illusory.

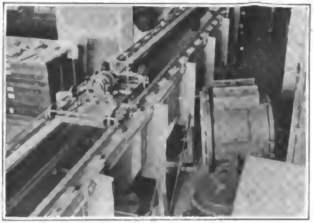
Privy Councilor O. Flamm, the well-known German authority on shipbuilding, who first enunciated this opinion, therefore decided to investigate the problem more closely in his private experimental tank at the Charlottenburg Technical High School. A propeller screw was arranged to work on a very light sand bottom, in conjunction with a series of rudders tested in succession. Photographic views were taken during operation through the water, which was lighted by means of huge naval searchlights, the sand bed being tested photographically after each experiment.

The results thus obtained are extremely interesting, and bear out completely the experimenter's views. Kinematograph films were prepared, which demonstrate the phenomena at issue in a striking manner. Recent tests at the Royal Testing Office for Marine Engineering and Shipbuilding (Charlottenburg) fully confirm Prof. Flamm's results.

After three years' experimenting, Prof. Flamm suggests the following solution of the problem: If a horizontal plate be fitted to the lower part of an ordinary rudder, the water lines deflected downward from the vertical part of the rudder are likely to be farther deflected in a horizontal direction, thus not striking the canal bottom. In order to ascertain whether this hypothesis is true, Flamm ordered an extensive series of model experiments to be made at the Royal Testing Office, on rudders of the most varied kinds.

Most careful experiments on a large scale were then undertaken on three vessels, in the name of the Prussian government, by the Fürstenwalde Department of Hydraulic Engineering, each individual test (lasting

Propeller without rudder, 440 revolutions, duration one minute.

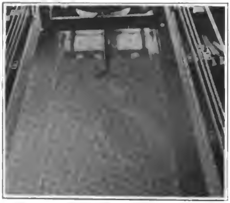


General layout of the apparatus employed in the investigation.

Protecting C
from Injury
Pro

Much injury is frequently done to
screw propellers, particularly to the
considerable variation in depth of wa
of the possibility of so weakening the
injury was for a long time thought to
iments shown in the accompanying
rudder that causes the trouble by di
from the propeller. The experimen
applied to the rudder of any craft

Influence of the protecting plates upon the canal bottom.



Simple rudder without plates, at angle of 30 degrees with axis of propeller.

Single rudder with plate, at 30-degree angle with axis of propeller.

Single rudder without plate, at angle of 30 degrees with axis of propeller. Shows stream lines deflected by rudder behind propeller; 530 revolutions per minute. Duration of experiment, 30 seconds. Pit, 15 mm. deep.

Single rudder with plate; 30 degrees to the axis of propeller. Shows stream lines deflected upward by the protecting plate. Revolutions per minute, 440. Duration of experiment, one minute.

Double rudder without plates, placed centrally. Distance between rudders, 180 mm; 530 revolutions per minute. Duration of experiment, 30 seconds. Very violent and irregular rippling of entire surface. Pit, 4 mm. deep.

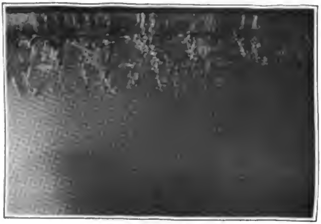
Double rudder without plates. Placed high in central position. Distance between rudders, 120 mm. Number of revolutions per minute, 550. Duration of experiment, 30 seconds. Modest rippling of the sand surface.

Double rudder with plates. Placed high in central position. Distance between rudders, 120 mm. Number of revolutions, 550. Duration of experiment, 30 seconds. Practically no rippling of the sand surface.

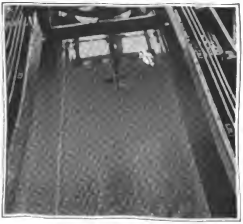
Double rudder without plates, placed high at 30 degrees with axis of propeller. Distance between rudders, 120 mm.; 550 revolutions per minute. Duration of experiments, 30 seconds. Very strong turbulation of the sand.

nal Bottoms rom Screw lers

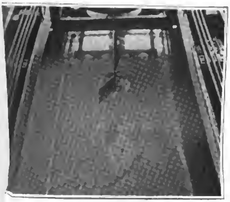
by the passage of boats driven by
toms where the erosion results in
d the formation of bars, not to speak
n that serious leakage occurs. This
used by the propeller, but the exper-
rations demonstrate that it is the
the direction of the flow of water
show a simple remedy that can be
ed in narrow or shallow channels.



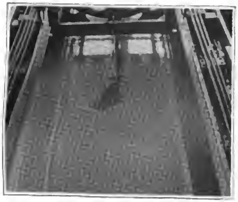
Propeller with air spirals.



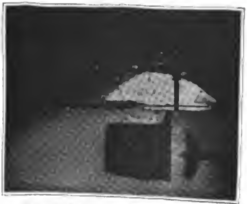
Turbulation by the propeller with rudder and without protecting plates.



Violent turbulation of the sand and formation of ripples.



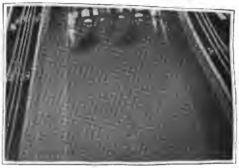
Slight turbulation of the sand and slight formation of ripples.



Single rudder in central position, without plate, shows stream line deflected by rudder.

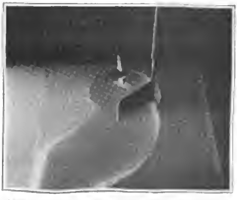
Double rudder with plates. Deep and in central position. Distance between rudders, 180 mm. Number of revolutions per minute, 560. Duration of experiment, 30 seconds. Slight rippling of sand. No pit formed.

Double rudder without plate. Deep; 30 degrees from central line. Distance between rudders, 180 mm. Number of revolutions per minute, 530. Duration of experiment, 30 seconds. Strong rippling of sands. Pit, 4 mm. deep.

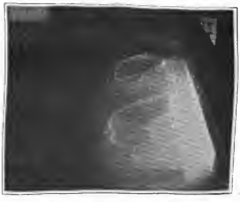


Double rudder with plates. Deep; 30 degrees from central position. Distance between rudders, 180 mm.; 560 revolutions per minute. Duration of experiment, 30 seconds. Hardly any rippling of the sand and no pit formed.

uble rudder with plates placed high, 32-degree
ngle with axis of rudder. Distance between rud-
ers, 120 mm. Number of revolutions, 550 per
inute. Experiment, 30 seconds. Slight rippling
surface sand and no pit formed.



Double rudder placed deep (represented by single rudder on starboard), without plates, 45 degrees angle with axis of propeller; 530 revolutions per minute. Experiment, 1 minute 10 seconds. Violent turbelation of sand, and pits 23 mm. deep.



In foreground formation of pit, 55 mm. deep. In background a second experiment, carried out under same conditions as third previous figure, showing same result as regards form and character of pit forms.

fully two hours) being duplicated, in order to eliminate any accidental circumstances.

The profile of the experimental truck (40 meters in length for each individual test, viz., 10 meters in front of and 30 meters behind the screw) was gaged carefully at intervals of 1 meter apart, by means of a raft 2 meters in width reaching across the canal section, thirty-one points being measured in each profile. This necessitated a total of about 30,000 readings. The vessels were moored in the middle of the canal and made to work in this position, indicator diagrams being taken continually, the number of turns being gaged, and the dynamometer traction read permanently. The most remarkable results obtained in this manner are summarized in the following:

The first set of tests was made on the steamship "Cæsar Wollheim VI," a single-screw vessel of 100 indicated horse-power, which had been fitted with the protective plate. The steamer worked for two hours, twice, without developing any appreciable erosion of the canal bottom.

Another test was made on the Diesel motor vessel "Cladow" (80 indicated horse-power), the screw of which, *after dismounting the rudder*, was allowed to work for twice two hours at its normal speed of 250 revolutions per minute, without there being any measurable erosion.

After thus confirming Prof. Flamm's theory, that erosion is due exclusively to the deflection, by the rudder, of the water jets thrown backward by the screw, the rudder fitted with the protective plate was placed in position, and the screw was again made to work twice for two hours. In spite of the most conscientious gaging of the canal bottom no trace of an appreciable erosion could be detected.

After then removing the protective plate, the screw was allowed to work with the same rudder as before, when enormous holes about 1.50 meters in depth were washed out of the canal bottom. It may be said that the draft of the vessel, in connection with these experiments, was 1.4 meters, and the water level in the canal about 3.20 meters, so that there were 1.80 meters of water left below the vessel and 1.90 meters below the lower edge of the propeller vanes.

A third set of tests was made on the Oder-Spree Canal with the steam tug "Dora," known to exert very strong erosive effects. This having been fitted with Flamm's protective plate, the screw was allowed to work twice for two hours, without there being an appreciable erosion. The plate was then removed and the screw allowed to work another two hours, when an excavation about 11 meters in length, 12 meters in width, and 1.81 meters in depth was produced.

Samples of the soil derived after the plate test, by means of big glass tubes, showed the clay layer to have remained unaffected, even the light mud on top of this layer being intact.

Another set of tests made with the freight steamer "Fritz," fitted with the protective plate, led to the following results. Behind the ship there was no erosion, only a small hole being produced below the propeller screw, by the suction effect of the latter.

From these results it is inferred that the plate, if properly dimensioned and conveniently arranged, affords full protection to the canal bottom, one of the most striking features being the absolute agreement between the model tests and experiments made under actual working conditions.

Further experiments were carried out in Prof. Flamm's experimental tank at the Charlottenburg Technical High School on all kinds of rudders as used in actual practice, with ships at rest as well as in motion.

Ordinary rudders were found to produce very considerable erosion, irrespective of their position. Screws without rudder likewise produced at least some erosion. Twin rudders introduced into the propeller current would, in their turn, give rise to heavy erosion. Erosion, however, ceased completely in all these cases, as soon as the rudder was fitted with the protective plate.

This simple safeguard thus affords an inexpensive means of preventing any damage to the canal bottom, and as the plate, moreover, augments considerably the steering capacity of the vessel, it will doubtless prove a welcome addition to present means of navigation. One question suggests itself, whether with these rudder plates the deflected current would not tend to depress the stern of a light boat.

Further experiments on a still larger scale, which are now in progress, bear out completely the above conclusions.

The Propulsion of Submarines

German and French Practice

The problems associated with the propulsion of vessels of the submarine class are of the greatest interest and call for the display of considerable ingenuity on the part of the engineer in combining the demands of the tacticians for speed, radius of action, capacity for maneuvering, and quick diving qualities with the allotment of the minimum space and weight. The change in propulsive machinery within recent years from gasoline and kerosene engines to those working on the Diesel cycle has made for greatly reduced dangers from the ignition of explosive mixtures of fuel vapor and air, and has increased to a considerable extent the radius of action. The Diesel engine being of German origin, it is natural that its adaptation to the propulsion of submarines—duties for which it is eminently suited—was early undertaken in Germany. The two German firms who have built the greater part of the engines of this type for German submarines are Krupps and the Maschinenfabrik, Augsburg-Nürnberg firms. Both firms have made many experiments in order to evolve the most suitable type of engine, and preference is apparently given to the two-cycle engine, although the M.A.N. firm also build successfully a four-cycle submarine engine which, from the official published data of tests of various types of high-speed Diesel engines, would seem to be well fitted for this kind of work.

TWO-STROKE ENGINES.

The firm of Krupp have specialized in the two-stroke cycle engine, and the method of scavenging they have adopted is by means of three valves in the cylinder head. The number of valves required for efficient scavenging is a moot point, and two are now generally regarded as sufficient. A greater number would doubtless conduce to the better clearing out of the burnt gases and the charging of the cylinder with fresh clean air, but the ensuing complications of valve gear generally call for the compromise of a smaller number of valves. For actuating the three-cylinder head valves Messrs. Krupp have designed a very neat valve gear, which has the virtue of simplicity. The fuel valve in the cylinder head of these engines is not vertical, but is inclined inboard to facilitate dismantling and to diminish the amount of head room required. The cylinders, liners, and heads are three separate castings, although the cylinder jackets are sometimes incorporated in the crank-case steel or bronze casting, which is made sufficiently strong to take the tension load.

In this engine the general arrangement is unique. In the center is the high-pressure three-stage compressor, on each side of which are grouped three working cylinders, while at the extreme end are double acting scavenging pumps. The provision of two scavenging pumps in comparison with the one usually adopted reduces the reciprocating weights of these parts and should make for a good balance. All these engines are directly reversible.

From the M.A.N. firm emanated the now famous two-stroke cycle stepped-piston type of engine, which type had for the main reason of its inception the reduction of weight and space occupied to an absolute minimum. The outstanding feature of design in this case lies in the form of the piston, which at its lower extremity is increased in diameter to form a crosshead to carry the gudgeon pin and to serve to compress the air necessary for scavenging. This piston works in a cast-iron liner let into the bronze crank-case, and the air is controlled by means of automatic valves. The advantages of this type of construction in reducing weight are considerable, and it is claimed that the weight works out at from 55 to 60 pounds per brake horse-power for engines of considerable size. The disadvantages are primarily those involved in the difficulty of successful piston design, since this part is subjected on the top to the hot action of the burning gases in the cylinder and at the bottom to the cooling effect of the scavenging air. This difficulty is now overcome by making the piston in two pieces.

In connection with the means of introducing the scavenging air into the working cylinder, it is interesting to record that the M.A.N. firm for their larger engines have discarded the single valve in the cylinder head in favor of two valves. The cylinders, again, in this design are cast in one piece—head, liner, and jacket. Two compressors with cranks in line are provided at the forward end of the engine to supply the air necessary for the injection of the fuel into the working cylinders and to charge the starting air bottles. This duplication aims at securing the reliability of one of the units of a modern Diesel engine that is calculated to give a certain amount of trouble. It must be realized that a breakdown of the compressor necessitates stopping the main engine, and the duplication referred to should probably enable the ship to proceed at almost full power assuming the breakdown of only one of the four compressors provided in a twin-screw vessel. These engines have been, it is believed, installed in German submarines, with eight cylinders giving 2,000 brake horse-power (250 brake horse-power per cylinder) or 4,000 brake horse-power per twin-screw vessel, which is the largest power so far adopted with oil engines of the light high-speed type—i. e., running at over 300 revolutions per minute.

M.A.N. FOUR-STROKE ENGINE.

This same firm at their Augsburg works have specialized in a four-stroke cycle engine, to the successful performance of which reference has already been made, and it is significant that, whereas drawings and information regarding the two-stroke cycle stepped piston engine of this firm have freely been given in the technical press of various countries, no detailed particulars whatsoever regarding the four-cycle engine are forthcoming. The 1,000 brake horse-power six-cylinder type, of which, it is believed, considerable numbers have been made, is remarkably light for its power, and the overall weight, especially when the extra fuel and lubricating oil consumptions of the two-stroke cycle engine are remembered, is little in excess of the two-stroke cycle engines previously described. Considerable ingenuity has been displayed in this design in fitting a neat reversing gear, as in foreign submarines equipped with Diesel engines direct reversibility is regarded as indispensable. The advantages of reversing the main engines are considerable when maneuvering; since the power developed by the main engines is always considerably in excess of that provided for by the electric motors installed for under-water propulsion. Again, the time necessary to reverse the main oil engines is not in excess of 10 seconds, which is very quick and considerably less than would be required to declutch the main engine and to reverse on the electric motor.

Besides these engines from the principal Diesel engine works in Germany, a large submarine is in hand at the works of the Italian constructors, the F.I.A.T. San Giorgio, in Spezia, and this submarine is to be propelled by engines of the well-known F.I.A.T. type of considerable horse-power. It is reported that these engines have successfully accomplished their bench trials, both for full power and for endurance. The two engines, it is stated, develop considerably over 2,500 brake horse-power. It may be mentioned that the dimensions of the latest type of German submarine are: Length, 213 feet 3 inches and beam, 20 feet. The displacement is 800 tons, and there are three torpedo tubes with two guns mounted forward.

THE USE OF STEAM.

The number of submarines actually built in Germany is given as 27, while 12 more are finished or in the course of construction. These numbers are much smaller than those for the French navy, which are given as 70 built and 23 building, the difference being due to the early pioneer work done by France in this movement. For the propulsion of the French submarines Diesel engines have not met with any considerable favor, and the majority of the boats are propelled by gasoline and kerosene engines. For the later boats steam turbines are being adopted. This propulsion by steam is not new, but is a reversion to early practice, which was abandoned in favor of internal combustion engines on account of the difficulties experienced in "closing down" the earlier boilers preparatory to diving and running below the surface on the electric motors. These difficulties, it is expected, will be overcome by the adoption of modern express water-tube boilers of rapid evaporative properties. Of these steam-driven submarines, four are being built at Rochefort of about 900 tons displacement, with twin screws driven through gearing by turbines of a total of 4,000 shaft horse-power, and two at Cherbourg of 950 tons displacement developing 5,000 shaft horse-power—the largest power yet applied to submarine propulsion. The results of this reversion to steam propulsion will be very closely watched by all submarine authorities, and if they are successful large developments in this direction may be expected in the near future. It is not to be understood that the French Navy have not applied Diesel engines to submarine propulsion, as in France a considerable number of boats are so propelled. The largest engine yet built is one of 2,000 brake horse-power, with eight cylinders.—*The Times*, London.

The Protective Treatment Against Typhoid Fever*

Typhoid fever is inseparable from war. It finds in war, ready for it, all that it could desire. In times of peace we have a thousand ways of avoiding it, a thousand ways of holding it up; so sure are our defenses, so elaborate our plans, that we get into a stupid way of thinking of typhoid fever as if it were due only to "insanitary surroundings"; as if it were a disease altogether unlikely to show itself within ten miles of a good medical health officer. Then comes war; and, with declaration of war, comes the general mobilization of the infective diseases. They are called up, they are sent to the front. Louvain as it was and Louvain as it is are scarcely more alike than are typhoid in times of peace and typhoid in time of war.

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* Stephen Paget in *Nature*.

Typhoid is, of course, already taking part in the present war. Given the allied armies and the German army in the western theater, how should there not be typhoid? The only question is, How much more will there be a month hence? The lateness of the year, happily, will kill off flies, which are great carriers of the disease; but the flies are not yet gone, and they will more or less repeat that deadly part which they took in the South African war. There is plenty of the disease for them to carry. "It is well known," says Sir Almroth Wright, in the *Times*, September 28th, "that the infection of typhoid is thickly sown all along the frontier of France and Germany." Besides, among two millions of men, there are bound to be some who have the germs of the disease in them. And what is the good of talking of "sanitation," as if our men could have the warm baths and the water-closets of the average Englishman's home? Let us take Dr. Johnson's advice, and clear our minds of cant. "An army," as Wright says, "on going out on active service goes from the sanitary conditions of civilization straight back to those of barbarism. . . . In war the doors are everywhere opened wide, both to the direct conveyance of infection by the excreta, and to its indirect conveyance by means of contaminated water. . . . On service, proper sanitary arrangements are very often impossible. We may think, for instance, of the situation of men in the trenches under fire. . . . When it comes to a tight place the alternative which will present itself will be that of drinking a polluted water or none. . . . It will, by the very nature of the case, be out of question to apply ordinary sanitary measures in an effective manner. . . . Infection spreads not only among the troops in the field, but also among the soldiers in hospital."

The *Daily Chronicle*, October 3rd, says: "It is reported that 800 Germans, on the lines between Brussels and Antwerp, are suffering from typhoid fever."

That the protective treatment is indeed protective we all know. It is the experience of the nations of the earth; and the whole world is agreed about it. France, India, Canada, the United States, Italy, let alone our enemies, are of one mind. Take only four instances:

1. *British Army in India.*—"The histories," as regards typhoid fever, of 19,314 soldiers, whose average period of service abroad was twenty months, were carefully followed, and every precaution possible was taken to verify the diagnosis bacteriologically. Of this number 10,378 were inoculated, and 8,936 not inoculated. The case incidence of typhoid fever among the inoculated was 5.39 per 1,000, and among the non-inoculated 30.4 per 1,000.—*Report of Anti-Typhoid Committee*, 1912.

2. *United States Army.*—"Inoculation was made compulsory in the American army in 1911, and has practically abolished the disease. In 1913 there were only three cases and no deaths in the entire army of over 90,000 men."—Sir W. Leishman, *British Medical Journal*, August 22nd, 1914.

3. *French Army.*—In 1912 typhoid broke out in the barracks at Avignon. Of 2,053 men, 1,366 were protected and 687 were not. The non-protected had 155 cases, with 21 deaths; the protected had not one case. The protective treatment was made compulsory last winter in the French army; and, in special circumstances, among the reservists.—*Lancet*, January 4th, 1913.

4. *Canadian-Pacific Railway.*—Throughout the "railways camps" in Alberta, during 1911, among 5,500 protected there were only two cases of typhoid; among 4,500 non-protected there were 220 cases.—*British Medical Journal*, June 6th, 1914.

It remains to be noted: (1) That the vaccine contains no living germs of any sort. (2) That the treatment, though it gave good results in the South African war, has been improved since that time. (3) That the avoidance of exertion and excitement, on the day of treatment, is a great safeguard against any disturbance of the general health. (4) That, when time allows, it is always best to give the vaccine not all in one dose, but in two, or even three graduated doses, with a few days between each dose.

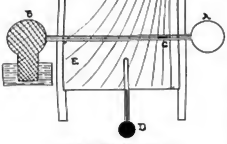
Sir Almroth Wright, by whose hands the gift of this treatment came to us, greatly desires that the treatment should be made compulsory, as in other armies, so in ours. Surely it is part of "my duty to my neighbor" that I should not, by having typhoid, expose him to the risk of infection from me. And it is certain that a soldier down with typhoid fever is not only useless against the enemy, but dangerous to his own friends.

A Direct Reading Psychrometer

By F. W. L. Peebles

Every weather bureau observatory uses a "wet and dry bulb" thermometer for the determination of the relative humidity of the atmosphere. The standard instrument is made up of two ordinary thermometers, as nearly alike as possible. One of them has the bulb covered with wicking which dips in water so as to keep the bulb wet. Water on the wet bulb evaporates and cools the mercury thus recording a lower temperature. The drier the air, the greater will be the evaporation and consequent reduction of temperature on the wet bulb side. The relative humidity of the air is computed from this difference. The capacity of the air for moisture varies with the temperature so that tables are necessary for the determination.

In the present instrument, which was designed by the writer, the use of tables has been eliminated and the readings are taken in per cent direct without any computation. Although it is believed that the device is original, it will not be patented, but rather, is hereby contributed to meteorological science by the designer.



A Direct Reading Psychrometer.

In the figure *A* is the dry bulb of an air thermometer, *B* is the wet bulb, *C* is a plug of mercury, *D* is an ordinary mercury thermometer for determining the air temperature and setting the sliding scale, and *E* is a calibrated chart for taking the reading. The wick of the wet bulb is provided with a reservoir of water so that the bulb may be kept continuously wet. The sliding scale is set with reference to the thermometer *D* so that a gauge point on it may be brought to the level of the top of the column thus setting the calibrated chart for the temperature of the air when the observation is made.

If both bulbs are dry the indicating end of the plug of mercury will register with the line marked 100 per cent. This would be interpreted to mean that no evaporation is taking place; and, as far as the instrument is concerned, that the bulbs are both at the same temperature. Under this condition the position of the plug is the same for all temperatures of the air and consequently the 100 per cent line is vertical on the chart. When evaporation does take place the plug moves in a direction toward the cooler bulb, and this movement is a function both of the difference in temperature and of the absolute temperature of the outside air.

In order to eliminate the part that the temperature of the outside air plays, the sliding scale is adjusted to the height of the column of mercury in the auxiliary thermometer *D*. It may be well to note that such an arrangement is not a true differential thermometer, on account of the fact that the same difference in temperature will cause more motion of the plug when both are at low temperatures than when at high temperatures. This feature is particularly desirable on account of the greater capacity of the air at high temperatures than at low temperatures.

In making up the instrument it is desirable that it be filled with a gas that is inert to mercury so that the plug is not acted upon in time. The bore of the connecting tube should be proportioned to the size of the bulbs so as to secure the right amount of motion to the plug. The tube should be of uniform cross section and the plug short so as to make the friction negligible.

In making up the instrument one bulb is sealed onto the tube and closed by the sealing, leaving only the opening to the tube. The second bulb is then sealed to the other end of the tube but this bulb is left with a tail to be sealed off later. The whole system is then filled with the gas desired and a drop of mercury is added for the plug. The tail is now closed at some distance from the bulb and then this tail is sealed off near the bulb. The bulb that has the sealing end on it may now be used for the wet bulb end so that the wick will cover the point of closure.

To adjust the plug the dry bulb is held uppermost and in contact with the palm of the hand so that some of the gas is driven into the other bulb. The apparatus is then inverted so that the mercury can enter the tube and the heated bulb allowed to cool so that the gas in the cooler bulb may enter the tube and drive the plug along before it. When the two bulbs attain the same temperature the plug will come to rest. Should its position not be correct this may be changed by driving it back and using more or less heat as the case may be.

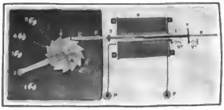
To calibrate the chart it is recommended that this be done by comparison with standard wet and dry thermometers and the table, although for those who have time for the mathematics it is easy to calculate the movement of the plug for different temperatures and differences in temperature of the two bulbs, and from this it is easy to calculate the relative humidity for any position of the plug. The rules for these computations may be found in any good text book in Physics.

A Device for Regulating Storage Batteries from a Distance*

In use the discharge of a storage battery the voltage gradually diminishes, so that, in order to maintain the constancy of lamps fed by the battery, it is necessary to add a cell (or to cut one out, if the cells are connected in opposition) whenever the drop in voltage amounts to about two volts. This is usually done by moving a multiple commutator on the switchboard, an operation that involves considerable trouble when the switchboard is located in the cellar or in a distant part of the building. A reliable and easily constructed device for operating the commutator from a distance by pressing a button is here shown. To the arm of the commutator is attached a disk, in the edge of which teeth of the shape illustrated have been cut with a fine saw or a file. The angle d_1Od_2, subtended at the center of the disk by each tooth, is equal to the angle 5O4, through which the commutator turns in passing from one contact to the next.

The sucking coil *B* is constructed as follows: The central tube is made of brass and is of square section, in order to prevent the square rod *DC* that slides inside it from turning. The end pieces are of thick sheet brass, and have projections which are bent at right angles and perforated for the reception of screws by which the coil is fastened to the board. The winding contains about 1,200 feet of wire 1/60 inch in diameter. The sliding rod is composed of an iron segment *C* and two brass segments, *D* and *E*. The iron is attached rigidly to the brass, but the two brass segments are joined at *F* by a flexible hinge, which allows the segment *E* to be lifted easily.

When a current flows in the coil the iron rod is drawn into the coil, carrying the brass rods before it. In this movement the rod *E* strikes a tooth of the disk and turns the disk through the angular interval between consecutive teeth, causing the commutator arm to advance from one contact to the next. When the current ceases the compound rod is drawn back by the spring *R*.



A device for regulating storage batteries from a distance.

In this reverse motion the hinged segment *E* rises above the next tooth and falls behind it, ready to push it forward when the current is again applied. The travel of the rod is limited by its cross-head *T* striking the screw-tops V_1 and V_2, which are so adjusted that the commutator arm stops exactly in the middle of each commutator contact, and the end of the hinged segment *E* falls behind the tooth with sufficient clearance.

The current may be taken from the storage battery itself by means of a branch circuit which includes as many cells as are required to energize the coil and turn the commutator. This circuit may be connected by very well insulated wires to push-buttons placed wherever they are wanted. When the lights grow dim another cell can be added to the battery by pressing a button. As the arm of the commutator is narrower than the space between consecutive contacts, the fact that the apparatus has operated is made evident, not only by the increase in brightness of the lamp, but also by the slight tremor in the light caused by the momentary interruption of the current.

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* From *La Nature*.

First life class making gardens.

Life class studying erosion.

An Experiment in Organic Education

Making the Course of Study Fit the Child

By Sidonie Matzner Gruenberg

WHILE we are waiting for Dr. Maria Montessori to try out her methods (SCIENTIFIC AMERICAN, June 22nd, 1912, page 564) with older children, we are informed that essentially the same principles have been applied in this country for seven years past, to groups of children from the kindergarten into the high school.

Mrs. Marietta L. Johnson, who worked on the theory and the methods of this experiment, was for years a teacher in a "regular school" in the West. Then she was a critic teacher in a training school and head of a department in a normal school. For a number of years after her marriage she did no teaching, but she apparently kept on thinking; for when it was time for her son to go to school she was unwilling to submit him to the "discipline" that she had seen imposed on thousands of other children.

Her reflections on the methods and the results of the ordinary schooling convinced her that our schools are fundamentally wrong. When an opportunity offered itself at Fairhope, Ala., to start a small class for her own child and the children of some of the neighbors, she resolved to abandon the classical methods in which she had been drilled and in which she had drilled other teachers, and to apply her deductions from certain modern scientific ideas. Mrs. Johnson traces the revolution in her outlook to two books that she read during the years of her children's infancy. These are Oppenheim's "The Development of the Child" and Henderson's "Education and the Larger Life."

The fundamental idea in the "organic" system of education is that "development is the only true education." As an organism the child in his development passes through fairly definite stages, in each of which certain instincts and needs are prominent. The school should therefore seek to meet the requirements of the child in each stage; thus alone can his further development be assured. Theoretically, all schools follow this principle. But Mrs. Johnson is the only educator in this country who has consistently followed this through all the grades, and on all sides of the child's nature and in connection with all of the school's work.

In the early years the child's instincts call for freedom and much activity; Mrs. Johnson keeps the children out of doors as much as possible and lets them do everything that children of that age care to do. Since the large muscles develop before the smaller ones, and since control can be best acquired when the muscles are developing, the younger children in the organic school are engaged in gardening, gymnastics, stone-throwing and other games, long before writing is thought of. The instinct to *make* things is exercised by opportunities to work in clay, clay-board, water-colors, and weaving. That younger children are far-sighted is recognized in the character of the activities, and no close work is put before them.

All these things sound very much like what is being done in thousands of other schools in this country and abroad. But these things are done in other schools spasmodically and as features added to the traditional course of study. Here they constitute the very heart of the course of study. Mrs. Johnson has done exactly what progressive educators have for years told us should be done, namely, she has made the course of study fit the child instead of trying to make the child fit the course of study.

Instead of making requirements for the child to meet, the organic school accepts each child as a personality and offers him an opportunity to do the best he can every day. The best of one child is not the same as the best of another child; one excels in this direction, another in that. And every child has more power in one direction than he has in another. Mrs. Johnson does not brand a child as stupid because he is weaker in arithmetic than his neighbors or because he is slower in a running match. "The test of the school," she says, "is the condition of the child. If every child is happy and busy and healthy, all is well.

This idea of free opportunity for doing the interesting thing because that is the educative thing, is carried so far that the school keeps no record of grades or achievement or attendance or promotions. Every child is promoted every year, or rather the promotion is continuous; every child does the best that he can and stays with his own group, instead of being obliged to repeat experiences from which he can probably not learn any more than he has already learned. There is no truancy problem, notwithstanding the absence of a compulsory attendance law, because there is no temptation to stay away from school. When the school is the most interesting part of the child's experience, he will naturally go to school whenever he is allowed to.

The absence of grading and of examination suggests to most people the absence of standards. But Mrs. Johnson has very definite standards, although they are not the same as those we have acquired from the schools and colleges. Mrs. Johnson's standards are a healthy body, an alert and active mind, and a sweet spirit. And all of the work at the Fairhope School is planned to produce these three sets of results.

For the health of the body there is an out-of-door activity adapted to the development and the strength and the needs of the child. For the mind there are the

Mrs. M. L. Johnson.

Learning to use their hands.

acquaintance with nature at first hand, the solving of problems in the making of things, the controlling of forces and of materials, the mastery of quantity in the measuring and weighing and calculating, the learning of stories from history and from literature, with their instinctive dramatization. There is constant translation of words into thoughts and actions. Finally, the health of the spirit is ministered to by the provision of "sincere experiences" in relation to other children and in relation to the forces and materials of nature and industry. There is joy in the work, because the work has meaning. Mrs. Johnson sees very clearly that half-hearted work is insincere, and that the attempt to develop "will-power" through arbitrary requirements more often cultivates dishonesty.

There are no set requirements for the first six years of the school. Then the children have an opportunity to learn to read; this they now do with avidity because they have learned that the books contain a great deal that they care about, and because their bodily and mental health makes the task very easy indeed. They learn to love books, because books have never been associated in their minds with anything disagreeable or burdensome. They easily learn to write, since they have muscular control and there is interest in the use of writing.

Mrs. Johnson's attitude toward the school as an institution is well expressed in the following:

Institutions to be educational must meet the demands of the individual, rather than make requirements which he must meet. An institution has no right to ask "What do you know?" "What have you done?" "Where are your credentials?" But must ask "What do you need?" "How may we serve you?" The "standards" of an institution are measured by its services, not by its requirements.

The first group of children with whom Mrs. Johnson began her experiment have reached the high school. In spite of their late start in reading, writing, and arithmetic, they were up to the "standards" set for children in the regular schools, and excelled the others in health, in intellectual power, in initiative, enthusiasm and spontaneity.

Prof. John Dewey visited the school during the past winter and was deeply impressed by what Mrs. Johnson has accomplished, particularly in view of the many local difficulties and the absence of special equipment or methods. "There are no new devices, no tricks of the trade, no unique or even peculiar appliances," writes Prof. Dewey. "What has been done is simply to provide the conditions for the wholesome, natural growth in small enough groups for the teacher (as a leader rather than as an instructor) to become acquainted with the weakness and powers of each child, and then to adapt the work to the individual needs."

This summer there was conducted a demonstration class and a normal class in the principles of organic education, at Greenwich, Conn., for the second time. Here teachers had an opportunity to become familiar with what is perhaps the most significant experiment in education yet undertaken in this country.

Street Sprinkling Trolley Cars*

Two street sprinkling cars have been put into operation on the tracks of the street railway of Hanover, Germany. The cars are provided and maintained by the fire department, which also furnishes the sprinkling operators and pays the railway company for the use of its tracks and power, and the services of the motormen.

The car first constructed proved so superior to the horse-drawn sprinkling wagons that a second car, of somewhat different construction, was soon added.

Each car has four axles and carries a cylindrical water tank of 3,170 gallons capacity. In the first car the water is expelled by maintaining, by means of a motor-compressor, an air pressure of one atmosphere above normal above the water in the tank. In the second car the stream is driven by a centrifugal pump. The latter method is simpler and cheaper than the former and it does not require the tank to be air-tight throughout. A 5 horse-power motor, which is used only during the actual sprinkling, suffices for the operation of the centrifugal pump, while a 7 horse-power motor is required for the air compressor.

Each car carries three sprinklers, one for the space between the rails and two for the roadway outside of the rails, and each sprinkler can be opened, closed and regulated, independently of the others. The maximum width that can be sprinkled is 85 feet. In the first car the sprinklers are opened and closed, and the width of the spray is regulated by a complicated system of levers, but in the second car all of these operations are performed by compressed air more promptly and accurately and with less fatigue of the attendant. Both cars have air brakes supplied by motor-compressors.

The average daily work of each car, working sixteen hours, includes 50 miles of roadway sprinkled, 12½ miles of travel light and 20 fillings. With an average width of spray of 36 feet, nearly 11,000,000 square feet are sprinkled in an average day.

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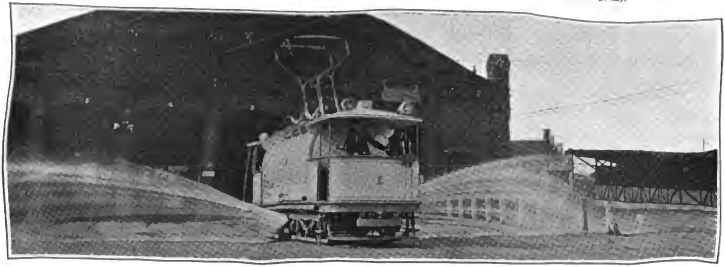
* From *Elektrische Kraftbetriebe und Bahnen.*



Street sprinkling trolley car. The spray jets are easily regulated.

Street sprinkling trolley cars in Hanover, Germany.

Design of Floats for Hydro-Aeroplanes—I*

Giving the Results of Tank Experiments with Various Models

By G. H. Millar, B.A.

THIS paper is founded on a series of experiments made by Mr. G. S. Baker and the author at the William Froude National Tank, at the instance of the Advisory Committee for Aeronautics. The work consisted of designing and running a large number of models of hydro-aeroplane floats, some of which have been subsequently built to. The special apparatus employed and methods of experiments are described in the Appendix, while the complete results are included in the Official Aeronautical Reports for 1912-13 and 1913-14. It should be borne in mind that the statements here made, and conclusions arrived at, are founded mainly on these model experiments, while many details can only be decided as the result of experience with actual machines.

Hydro-aeroplanes may be divided, broadly, into two classes: (1) Those in which the machine follows the same general lines as a land machine, with floats substituted for the landing-gear; (2) those in which the fuselage is in the form of a boat containing the crew, and sometimes the engine. The term "hydro-aeroplane" is usually confined to machines of the first class, those of the second being termed "flying boats." These two classes are being developed side by side; in some cases both are built by the same manufacturers. The second class is specially popular in America. It is as yet too early to say which will ultimately prove the more useful, but possibly both types will persist, each for its own purpose. This paper is mainly concerned with the first class, the hydro-aeroplane proper, although most of the conclusions come to are applicable also to the "flying boat." At first sight, the latter may appear to be the more seaworthy device; but with a large open cock-pit it is exposed to great risk of swamping. The Curtiss flying boats are fitted with water-tight bulkheads, and have a very large total buoyancy (usually four and a half times the weight of the machine), but this necessitates a large boat, which even then cannot altogether take the place of the fuselage of the land machine, especially if the engine is carried overhead.

Turning now to the hydro-aeroplane proper, the machine may be supported either (a) by a single broad main float, with small subsidiary wing floats, or (b) by a pair of floats side by side at a suitable distance apart. In either case a small tail float is usually fitted, which may rest on the water at the lowest speeds, or may be clear of it even when the machine is at rest, and only relied on to prevent the tail of the machine dipping if it is thrown backward by a sudden gust of wind. It is, however, usually preferred to have the center of gravity of the whole machine aft of the center of buoyancy of the floats, which, of course, requires that the tail float shall take some of the load at rest. This also makes the machine float more steadily in a short sea, and allows an underwater rudder to be used to assist maneuvering on the water at low speeds. In any case the load on the tail float is small, and its design of no particular moment.

Considering the main floats, the general balance of opinion seems to be decidedly in favor of twin floats. With a single float the lateral stability (on the water) is small, unless the float is unduly broad for its length, and wing floats become essential. On the other hand a pair of floats placed too far apart may cause a severe slewing strain if one becomes more deeply immersed than the other. As regards efficiency, experimental results show that if a pair of floats be replaced by a single one of similar design but double the breadth, much the same results will be obtained, although the water disturbance is more noticeable. The performance of twin floats is not appreciably affected by their distance apart, provided that the gap is not less than the breadth of either float. It is generally agreed that the total buoyancy of the floats should be at least twice the dead-weight of the machine, and water-tight bulkheads are frequently fitted. These incidentally prevent any water that may leak in from flowing from end to end of the float when in the air. The air resistance of the floats must be taken into consideration, and their construction is a matter of some difficulty, great strength being required with a light weight.

The design of hydro-aeroplane floats is naturally very closely allied to that of hydroplane boats, though with some important differences. Since the lift of the aerofoils increases continuously with the speed, and ultimately becomes equal to the weight of the whole machine, it might be thought that any fine lined ship-shaped form would be suitable for a float, but this is not the case. Fig. 1 shows the curve of lift for an aeroplane of "W" pounds total dead-weight designed to leave the water at a speed of V foot-seconds, it being assumed that the angle of attack is constant throughout. This curve is simply a parabola described to touch the axis Ox at the origin, and to pass through the point $P\ (V, W)$. The ordinate at any speed v (less than V) is, of course, $\left(\frac{v}{V}\right)^2 W$.

Now it will be seen that the lift is comparatively small until a high speed has been attained; at half speed it will be only one-quarter of the dead-weight of the machine. But even this speed is a very high one for the length of the float, and consequently for a float not designed on hydroplane principles the resistance and wave-making will become enormous before the air lift becomes appreciably great, and the machine will never reach its flying speed, unless with a strong head wind.

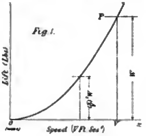


Fig. 1.

It may here be well to consider the principles on which hydroplane design is based. Any normal form of vessel will rise and skim along the surface of the water if she is towed fast enough. But in the case of a ship designed for low speeds, the speed at which she begins to rise is a very high one, and up to this point wave-making and resistance will increase to a prohibitive extent.[1]

Now, a hydroplane is so designed that when a high speed is attained the normal pressure of the water on the hull shall have a large vertical component, which raises the boat and so decreases her displacement, and, consequently, the wave-making. The simplest way of attaining this result is to provide the boat with a flat bottom, which, at high speeds, shall have an inclination of about 5 degrees to the horizontal, in a fore-and-aft direction.

FLAT PLATE RESULTS.

Fig. 2.
LIFT/DRIFT CURVES AT FIXED IMMERSION; VARYING INCLINATION.

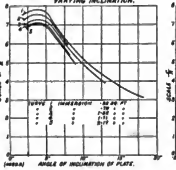


Fig. 3.
LIFT/DRIFT CURVES AT FIXED INCLINATION; VARYING IMMERSION.

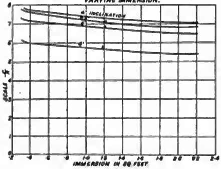


Fig. 4.
LIFT COEFFICIENT CURVES AT FIXED IMMERSION; VARYING INCLINATION.

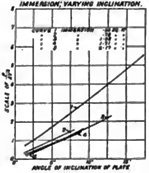


Fig. 5. RESISTANCE CURVE FOR FLAT PLATE, 6" WIDE, AT 6° P-4·06 LBS. AT ALL SPEEDS.

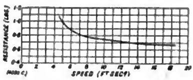


Fig. 6.

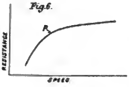
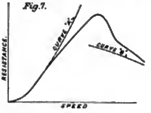


Fig. 7.



Figs. 2, 3 and 4, on this page, show the results of some experiments made on flat plates at the William Froude Tank. The plates were 1 foot wide, and were towed on the surface of the water at a series of small angles, and at speeds of 600 feet, 800 feet, 1,000 feet, and 1,200 feet per minute. The immersion was also varied independently, and the vertical force P and horizontal force R on the plate were measured. In the figures, V is the speed in feet per second, and A the area of plate immersed in square feet. The plate being 1 foot wide, the number denoting this area also denotes the length of plate immersed and the ratio $\frac{\text{length immersed}}{\text{breadth}}$, which is the inverse of the aspect ratio. These results cannot be taken to be very exact, as there was a considerable variation of $\frac{P}{AV^2}$ and $\frac{R}{AV^2}$ with speed, although an uncertain one. This may have been due to two causes—to the variation with speed of the actual area immersed for a given value of A (which was the area immersed when the plate was at rest at the same angle and height); or to errors in estimating the position of the center of pressure, which could not be directly measured with the apparatus then in use.

---

* Paper read at the joint meeting of the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-on-Tyne. Reproduced from Engineering.

[1] In the case of a mercantile form model run at the William Froude Tank, for a ship 400 feet long, the E. H. P. required at 14.8 knots was 4,115, and at 16.5 knots was 10,900, the resistance increasing as the sixteenth power of the speed between these points.

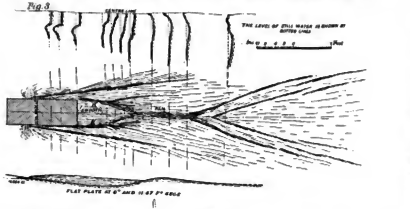
Fig. 3 shows that the efficiency of such a plate increases with increase of aspect ratio, but that the effect is not a very marked one, over the range here considered. At large aspect ratios the efficiency seems to increase considerably, and, with single-plane floats at high speeds and small loads, efficiencies of as much as 10.5[1] have been obtained, although this was perhaps a little too high. With a plate of an aerofoil section and an aspect ratio 6 : 1, having its chord at 4½ degrees, and its leading edge just above the water surface, an efficiency of 11.8[1] was obtained.

Fig. 5, above, is deduced from Figs. 2, 3 and 4, by calculation, and shows the resistance of a plate 6 inches wide at a constant angle of 6 degrees and a constant load of 4.86 pounds at speeds of 10 feet to 18 feet per second. It will be seen that the resistance actually falls as the speed increases over this range. The curve cannot be extended down toward zero speed from the experimental results, but it will be obvious that at a very small speed a very great length of the plate must be immersed to support any load; hence the curve, if produced toward zero speed, must be of the nature shown by the dotted line—i. e., asymptotic to the axis of resistance.

Fig. 6 shows the general appearance of the curve of resistance to a base of speed for a hydroplane (having a constant load). It will be seen that at the point *P* the rate of increase of resistance rapidly falls off. This is the point at which the boat commences to rise in the water, and after this the resistance only increases very slowly. In the case of a hydro-aeroplane float running at a constant angle the load is constantly decreasing; the load at a speed v is $W\left(1-\frac{v^2}{V^2}\right)$, where V is the speed at which the machine begins to fly and W the dead-load. Hence, the curve of resistance to a speed base takes the form shown in Fig. 7, having a "hump" (which may be sharp and peaky or flat and spread out) at the point where the float begins to rise in the water, and afterwards falling off rapidly till at the flying speed it denotes the air resistance of the float. In the same figure, curve "*A*" denotes the resistance the float would have if constantly kept at the same vertical height and prevented from rising; curve "*B*" denotes the resistance of a flat plate carrying the same load as the float. The curve for the actual float tends to follow curve *A* at moderate speeds and curve *B* at planing speeds, the hump representing the intermediate stage when the float is rising sharply in the water.

The problem of designing a hydroplane that shall have a small resistance at a planing speed is a comparatively simple one. But the requirements for such speeds differ considerably from those for low resistance at moderate speeds. As a matter of fact, at speeds up to the "hump" speed any hydroplane is a very bad boat. Consider first the requirements at planing speed. Fig. 8, above, shows the wave system generated by a flat plate towed along the surface at a high speed and small angle (6 degrees), the fore end of the plate overhanging. It will be observed that the plate scoops out a hollow in the water, which does not fill up until some way astern of it. The water which passes underneath the plate issues at the back in a smooth stream, which at first follows the direction of the plate, but gradually turns upward again. From the crests of the bow diverging waves the surface slopes down to this smooth region, meeting it in a well-defined line. At the points *K*, *K* two converging waves appear to leave the inner walls of the diverging waves, and these meet to form a curious "fan" of partly broken water. At the after end of the "fan" another diverging system starts with a smaller one inside it. This system is really a continuation of the converging waves which cross at the "fan."

Fig. 3



The whole system is merely an extreme case of that of an ordinary high-speed ship, where the "fan" occurs as a region of high-pressure under the after end of the ship. The diverging system aft of the fan corresponds to the ordinary stern diverging system. In a high-speed destroyer, the "fan" may sometimes be seen clear of the stern. If it is just underneath the stern, the space bounded by the diverging waves aft of it will appear as a plateau of broken water.

Fig. 9 shows a transverse section of the plate and the bow diverging wave. The latter will change from type 1 to type 2, and from type 2 to type 3, if the speed be decreased, or the depth of immersion of the element is increased, and the same gradual change occurs as we go aft along the plate. That is to say, the inner wall of the wave becomes steeper and more convex up to the point where the crest has its maximum height. Now, suppose the plate to form the bottom of a float with vertical sides. Type 1 wave will go clear of the sides, type 2 will just do so, but type 3 will force a thin film of water up the side of the float, which will add very considerably to the resistance. Again, where the wave is of type 1, the sides may be flared considerably, without touching the wave, and where the wave is of type 3 they must "tumble home" from the bottom to clear it. With a vertical-sided and flat-bottomed float thin filmy waves will always rise against the side of the float at a moderate speed, which will gradually move aft as the speed increases till they leave it altogether. The sketch in Fig. 10, below, shows their appearance when the speed is reached at which they start to leave the float. These clinging waves may, however, be thrown clear of the sides by the use of bilge-planes (better known, perhaps, by the facetious title of "mud-guards").

The waves set up by our elementary plate will not be affected if we build up a boat form upon it, provided that the total load is the same, and that no part of the boat except that formed by the plate touches or comes very near to the surface of the water. In particular, it may be observed that by forming a step at the back edge of the plate we may build on a tail to the boat aft of this point, which will be completely clear of the water at a certain speed. To make the sides of the boat clear of the waves at the lowest possible speed, they should have increasing tumble-home toward the after end, while they may be flared a little at the forward end. The use of tumble-home on the after part of the sides is, however, not without its objections in the case of a hydro-aeroplane float, as it tends to throw the water up when turning. We have so far considered a boat or float having only a single "planing" surface. We may, however, have any number of such surfaces separated by steps. Each plane will then set up its own system of waves, and the diverging crests from one plane may even cross the crests from the plane ahead of it.

It is not difficult to design a float which shall have a good efficiency at "planing" speeds. But this is not nearly so important as the behavior of the float at lower speeds. From a resistance point of view, the important range of speed is that up to the "hump" on the resistance curve, during which it must be considered as a displacement boat.

The essentials for good "planing" are:

1. Considerable overhang at the forward end with short immersed length and suitably-shaped bottom.
2. That the water should leave the bottom of the boat on a sharp edge both at the stern and at the sides.

For a fast displacement boat we require:

1. A fine curve of sectional areas, and consequently great length with small beam, or light draught.

Fig 9

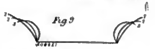


Fig. 11.

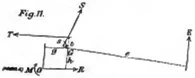
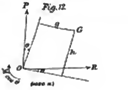


Fig. 10

Fig. 12



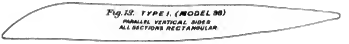


Fig. 13. TYPE I. (MODEL 38)
PARALLEL VERTICAL SIDES
ALL SECTIONS RECTANGULAR

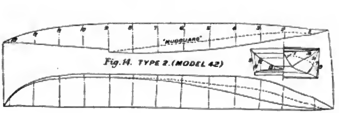


Fig. 14. TYPE 2. (MODEL 42)

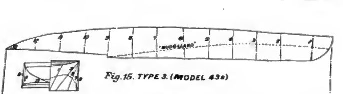


Fig. 15. TYPE 3. (MODEL 43a)

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[1] This is the value of the ratio $\frac{P}{R}$.

2. No sharp corners or edges in contact with the water; they produce eddy-making, and consequent waste of power.

3. Smallest possible wetted surface to reduce surface friction. This is not so important as condition 1, except at very low speeds.

We have, therefore, to try and satisfy two sets of conditions which are in some respects antagonistic.

First, as regards length. At speeds below the "hump," increase of length and decrease of breadth produce considerable improvement. At "planing" speeds they are slightly detrimental, and will probably cause the "hump" to come at a slightly higher speed, but in the case of a stepped float this may be partially counteracted by the fact that the narrower float will require less air at the steps. On the whole, a float can always be improved by increasing the ratio of length to breadth up to an excessive limit. From a practical standpoint, very long floats are highly undesirable; a good float can be got out on a length to breadth ratio of about 5½ to 1, and in the author's opinion a ratio of about 6 to 1 should not be exceeded, although a good many floats have a ratio of 7 to 1 or more.

It has been seen that for a flat plate the most efficient angle is 4 degrees, and for a float having a flat planing surface the best results would be obtained with the surface at the same angle. In practice, however, it is better to design the floats to run at a slightly greater angle, so as to give a greater margin of safety when alighting. In the series run at the William Froude Tank, the normal running angle was taken to be 6 degrees for the forward or main planing surface, or in the case of a cambered surface the mean angle was 6 degrees. The model floats were made to a scale of $\frac{1}{12}$ for a machine of 2,200 pounds weight designed to leave the water at a speed of 67 foot-seconds in a calm. For convenience, these figures will be taken as the standard for the rest of the paper.

It might be thought that the pilot would be able to run the machine on the water at any angle he desired, just as he can in the air; as a matter of fact, the water forces on the float may introduce very large trimming moments, quite outside the pilot's range of control. The magnitudes of the moments brought into play are therefore a very important part of the design. Suppose that for a given float, or pair of floats, running at a given angle and speed, the reaction of the water on the floats is represented by vertical and horizontal components P, R pounds, and a moment of M foot-pounds, about some point O; these quantities can be determined from model experiments. Let G be the center of gravity of the whole machine (including the floats), and let the horizontal and vertical co-ordinates of G relative to O be $(g\ h)$ feet. Let T be the thrust of the propeller, and t the distance of its line of action from G.

Also let the force on the elevator and tail-plane be E pounds acting in a line distant e from G, and let S be the resultant resistance of the machine (apart from the floats) acting in a line distant s from G.

Then for angular equilibrium we have, with the convention of signs shown in Fig. 11:

$$Ee + Tt - Ss = M + Pg - Rh,$$

the trimming moment being reckoned positive when it tends to depress the tail of the machine. The expression $Tt - Ss$ is usually very small; for a machine of the weight considered, at a speed of from 30 to 40 foot-seconds, it will probably not exceed 150 foot-pounds at the most; and a calculation of the elevator control (Ee) for a specific machine of this weight gave the following maximum values:

Speed, ft. secs.	10	20	30	40	50	60
Control, ft.-lb.	68	272	632	1088	1700	2528

We can therefore calculate the limits within which the moment $M_0 \equiv M + Pg - Rh$ must be kept if the machine is to be run at its designed angle, although these limits may be exceeded momentarily.

The value of M_0 at any speed and angle is, of course, very largely dependent upon the position of the floats relative to G—that is, on the value of g, h. For the machine considered G is at a height of about 6.3 ft. above the bottom of the floats, so that the part of $M - Rh$ due to resistance is of some importance. Now the height of G, and, therefore, the value of h, will be decided on in the early stages of the design. We therefore require a simple means of determining the most suitable value of g. One method of doing so is as follows:—The values of M, P, R, referred to a definite point O, are determined from model experiments for a range of speeds and angles and the value of h is decided on. Consider, first, the case in which the angle is constant (say 6 deg.) and the speed varies. Then $M_0 = M - Rh - (-Pg)$.

On a base of speed plot the values of $-Pg$ ft.-lb. for $g = 1$, i. e., of $-P$ ft.-lb. (Figs. 21, 24, and 26, next issue) The result is an inverted parabola, which, by distorting the abscissa scale, can be reduced to a straight line. Pg will now for every value of g be represented by a straight line, all such straight lines radiating from a point in the base line. At the distorted abscissa points erect ordinates denoting the values of $M - Rh$ and join up the ends of these ordinates to form an open polygon. Then, taking **any desired value of g, the value of M_0 is given by the** distance from the corresponding Pg line to the polygon curve, being positive if measured upwards, and negative if measured downwards. We can thus see by inspection the effect on the moments of altering the value of g.

We also require cross-curves showing the value of the moments at constant speed and varying angle, which will show us what change of trim (if any) is likely to take place at any speed. Similar diagrams can be prepared for this case. In the model apparatus used at the William Froude Tank the value of M as read is only strictly correct at 6 deg. inclination of float. At any other angle (6 deg. + θ deg.) the true moment is $M\cos\theta$, while, whatever the angle, P and R are always measured vertically and horizontally.

Hence (see Fig. 12) the moment is now—

$$M_0 \equiv M\cos\theta + P(g\cos\theta + h\sin\theta) - R(h\cos\theta - g\sin\theta),$$

which may be written:—

$$M\cos\theta + h(P\sin\theta - R\cos\theta) - [-g(P\cos\theta + R\sin\theta)].$$

We now plot $-g(P\cos\theta + R\sin\theta)$ ft.-lb. to a base of angle for $g = 1$, and distort the abscissa scale to make it a straight line; then plot $M\cos\theta + h(P\sin\theta - R\cos\theta)$ at the new abscissa points, and proceed as before (see Figs. 22 and 23). In this case, θ being small, a rough approximation may be obtained by plotting $-P$ instead of $-(P\cos\theta + R\sin\theta)$ and $M - Rh$ instead of $M\cos\theta + h(P\sin\theta - R\cos\theta)$, and spacing the ordinates at any convenient distance apart. If the variations of P with angle be also neglected,[3] we get a straight line parallel to the base.

We require some point of reference for the horizontal position of the C.G., and the most convenient one is the position of the center of buoyancy of the float when fully loaded and inclined at the standard angle of 6 deg. The value of g to bring this point vertically under the C.G. is then calculated, and the corresponding line drawn on the moment diagram. We can then readily see the effect of placing G at any desired distance aft of the C.B.

It is now proposed to consider some float design in detail. Fig. 13, above, shows a type of float that has been more widely employed than any other. It is simple to construct, and has given good service in practice. It has a rectangular water-line at all speeds, and therefore should have fine bow-lines; but, as usually made, the curve of areas is not particularly fine forward. This is, however, partially compensated for at moderate speeds by the large amount of lifting surface, which causes the float to start rising in the water at quite low speeds.

Cling waves form against the sides, and do not leave them until rather a high speed is attained. The long overhang required forward makes the float very stable at small angles, but otherwise is so much wasted length. Such a float naturally tends to "slam" badly in a short lop. Floats of this type are sometimes fined at the forward end by pinching in the sides.

Figs. 14 and 15 show two floats of a very different type that were included in the series of floats evolved at the William Froude Tank. Of these, type 3 (Fig. 15) is the better, its flat under surface being all at the most efficient angle. Both these have tail appendages, which leave the water completely before the hump speed is reached if the floats are maintained at an angle of 5 deg. to 6 deg.

(To be concluded)

Corrosion of Condenser Tubes

In many places the destruction of condenser tubes through pitting or corrosion results in considerable expense. An article by Mr. E. Bate in the *General Electric Review* deals at some length with causes tending to the pitting and corrosion of condenser tubes. These causes may be briefly stated thus: Stray currents from earthed systems, galvanic currents between the dissimilar metals of which the condenser is constructed, galvanic currents due to deposits of active material inside the tubes, use of unsuitable mixture for the material of the tubes. The increasing use of negative boosters on earthed systems prevents the first-mentioned point from being of serious importance. Regarding the second point, the alloy of which the tubes are usually composed is electro-negative to the cast iron casing, so that no corrosion of the tubes could be caused by these currents. That the third cause is responsible for the greater majority of tube failures is borne out by the fact that 98 per cent of the tubes examined by the author were pitted in the lower half, where, of course, all internal deposits would collect. It is suggested that in cases where the circulating water is drawn through a long line of cast iron piping, oxide of iron and carbon may be deposited in the condenser tubes, thus giving rise to injurious electrolytic action. The author is of opinion that, once local corrosion has commenced, it cannot practically be stopped. A suggested method of preventing this deleterious deposit in the condenser tubes is to treat the interior of the cast iron piping so as to prevent corrosion, and to keep the intake pipes as short as possible.

Fog Signals by Wireless

In the Firth of Clyde, in Scotland, several fog signal stations have been established which are operated entirely by wireless currents sent from a distant station, and require no attention other than the periodic replenishment of the necessary supplies. The signal is in the form of a gas gun in which a charge of acetylene gas air is fired at regulated intervals so that it identifies itself. The gas admission and ignition is quite automatic, and once the gas is turned on the cycle of operations proceeds regularly. All that is required is to control the gas valve electrically, so that it can be turned on in time of fog. The needle valve used for the purpose is actuated by two electromagnets, one for opening and the other for closing. These are controlled by a relay working in conjunction with a special form of coherer, which receives the signals through a jigger transformer. The principal feature of the apparatus is the selective synchroniser, by which the apparatus only responds to a particular signal, different signals being employed for the turning on and turning off circuits. A 14-foot receiving aerial of five wires is used, and the transmitting apparatus is of the simplest character, embodying synchronizers of similar nature to the receiving synchronizers for giving the correct signals.

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[3] The effect of neglecting this is to decrease the moment numerically at angles below 6 degrees, and to increase it numerically at angles above 6 degrees.

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Photograph by Meurisse.

Cuirassiers of the French army assisting a wounded comrade.

THE CARE OF THE WOUNDED IN THE PRESENT WAR.—[See page 328.]

Muscular Activity and Thought Processes

Various Psychological Theories Reviewed

By Knight Dunlap, Associate Professor of Psychology in the Johns Hopkins University

The psychology current to-day is founded on a doctrine of imagination which is so simple and so generally accepted that it seems as assured as the law of gravitation. The *mental image* is supposed to be an actually existing object, although in the "mind," and to be as observable as are the qualities of external objects. In fact, as is well known, there have been many philosophers who have maintained that what we call the "external" world is nothing but the system of mental images of him who observes it. Many more, while rejecting this sweeping theory of "subjective idealism," have insisted that all we directly know or observe is exhausted by the "mental images" and their interrelations, and that therefore our knowledge of the "outer" world is indirect, and is possible only because our "mental images" represent, or in some way correspond to, this outer world. This latter theory ("dualism") has been the source of some trouble to its adherents when they have tried to explain just how we know that our images do correspond to the outer realities, since we are unable to observe anything but the images. But the theory has nevertheless been held by the majority of educated men since the sixteenth century, and has with few exceptions been explicitly or tacitly assumed by the professional psychologists of the last forty years.

Psychologists, however, have recognized two classes of these "mental images," and have for the most part applied the name to one class only, calling the other class *sensations*. We shall, therefore, from this point on, take the term "mental images" as restricted in this way. "Sensations" are produced in the "mind" when certain features of the external world (called *stimuli*) act on the nervous system. Thus, ether vibrations of a certain rate impinging on the retina of the eye, excite the minute nerve endings called *cones*, and through them the nerve cells within the brain, and ultimately muscles throughout the body; and the "sensation of red" is produced.

"Images," on the other hand, are produced by the action of the nervous system without the excitation by a stimulus. Thus, when I close my eyes and imagine red, it is assumed that the red in this case is an "image." Just as there is an "image" of red, there may be "images" of blue, of yellow, of sweet, of sour, of musk or of any other quality the senses give. Not all minds, however, possess all types of images to the same extent. Some persons are predominantly "visualizers," and in their mind the visual image occurs very distinctly and freely, whereas auditory images occur less freely and are vague, while images of smell and taste may be practically absent. Other minds are "auditory," and a few may be strongly "olfactory," and so on. A great deal of work has been done in the attempt to devise methods for determining the "type" to which a given person belongs, and a great deal of emphasis has been laid on the importance of making these determinations. This work was started by Francis Galton, and has occupied a prominent place in modern so-called experimental psychology. It will be readily seen that if these type distinctions are important, the knowledge of the type to which a child belongs may determine the method of presentation of material he is required to learn. The "auditory" child may learn more easily what he hears, whereas the "visual" child may learn more readily what he sees.

According to the conventional psychological view the sensations and images, with their interrelations, really make up all we can observe or of which we can be conscious. There has been a long dispute in psychology as to whether the relation should be admitted as a specific subject for psychological investigation, but this is a technical matter which has no present interest. We can here confine ourselves to the study of the sensations and images, assuming that the relations are perceived.

When I imagine, or remember, or think, I am attending to *images*. When I perceive, I am attending to sensations and images together: for it soon becomes evident that pure sensations are practically never found. When I perceive, the object of my perception is constituted by a few sensations and many images. The apple on the table before me is not a mere sensation of red, but contains in addition the images of the resistance, coolness, sweetness, tartness, etc., which I have previously experienced. If this were not so, a painted apple and a real apple would be the same for visual perception, whereas they are usually not the same.

The sensation and the image are not without points of similarity. The exact points of difference, in fact, have long been the subject of dispute among psychologists. Many hold that the essential difference is in *intensity*; that the image of a candle flame differs from the sensation of a candle flame, for example, principally in being far less bright. Others hold that the image has *no intensity whatsoever*: that there are no brightness differences in images of light of various brightnesses. One image may *represent* a bright light, and another *represent* a dim light, according to this view, but there can be no difference in the brightness of the images, because neither of them has any brightness at all. Another theory of the difference between image and sensation is that the latter is more vague, less sharply defined than the former.

In recent years several painstaking studies of images have been made, with the hope of deciding these vexing questions. The results have not been all that could be desired; some observers deciding that images have intensity, others that they have not, etc. The studies, however, have shown one thing very clearly: psychologists of all the orthodox schools look on the images as very definite and observable entities, having the same qualities as do sensations, and regarded practically as *copies* or modified reproductions of sensations.

The great difficulty with the doctrine of images has been in making it actually cover what we commonly call *thought*. When I "think of" an ink bottle which is in a room a mile from here, the fact is (according to the orthodox doctrine) that I have at present in my mind an image of that bottle. It is not contended that the image is necessarily a *visual* image of the bottle: an image of the sound of the words "my ink bottle" may serve the purpose. The question is, how do I know this image is the image of that particular bottle? This knowledge is necessary, if the image is to help me think of that bottle as distinguished from others. The answer customarily made is that the image *means* that bottle. *Meaning*, in other words, is brought in *ex machina* to bridge the gap between the image and the bottle a mile away. So if I am thinking of a fire which burned yesterday, *meaning* bridges the gap between the image I have to-day and the fire which existed yesterday.

In effect, therefore, I am conscious of the image, and also conscious in another way of the object to which it refers, and hence know that the image refers to the object. A full explanation, although complicated; but what is the use of the image?

Such discrepancy, together with the reports of certain persons of intelligence who claim they have never had any "images" such as psychologists describe, have kept alive continuous opposition to the orthodox theory of image, and a significant movement in psychology to-day is toward the rejection of this theory. This movement has been foreshadowed by two other movements, one profound and the other more superficial: the "new realism" in philosophy, and the "imageless thought" movement in psychology.

The "new realism" began with Prof. James' rejection of the doctrine of the traditional "mind," and has a diversity of expression at the present day. The general movement is a rejection not only of the "mental images" of the psychologist, but of the "sensations" as well. The four-hundred-year-old notion of an "inner world" to which we are limited, and through which we know an "outer world," is given up. What we know are *real objects*. The color, for example, which psychologists have been insisting is a "sensation" in a "mind," is for the new realist a real object, as "external" as anything can be.

Like most profound revolutionary movements, "new realism" goes too far. In addition to denying a world of "mental" objects, the various sorts of "new realists" deny the existence of an ego or knower. The new realistic theories of how knowledge or experience occurs at all are too complicated to be briefly presented, but it is not unfair to say that the various objects in the world are supposed to experience one another.

The other movement to which I have referred, that of "imageless thought," does not reject the orthodox formulation of psychology, but attempts to add to it. Various psychologists who accept images quite faithfully have observed that thought does occur in cases where no "images" can be found. Hence they have added to "sensation" and "image" another category of mental objects, which are variously called by various theorists "Bewusstseinslage," "Wissens," and other terms which will not submit to English translation. This movement, although without any positive issue, is serving to unsettle psychological theory, and is a preface for a more fundamental revision.

Let us now go back and examine the processes of thought and perception. It is evident, even on the theory of images, that one can be conscious of objects and events in two ways. One can be conscious of what is *now here*, and also one can be conscious of what was or what is *elsewhere*. In short, one can *perceive* and one can *think*: the two forms of consciousness are *perception* (we might well revert to the term *intuition*) and *thought* (including memory and imagination). These forms of consciousness are fundamental, and no psychology has ever been able to dispense with the distinction between them.

As regards the *things of which we are conscious*, we may continue to call the objects of perception *sensations*, understanding by that term its literal significance of *those things which are perceived through the senses*. But the objects of thought are then sensations also, at least in many cases, and not any mere "copies" of sensation. The difference is not in the *object* of consciousness, but in the fact that in the one case we *perceive* (or intuit) them, and in the other case, *think of them*.

The doctrine of the "image," however, is a crude recognition of the fact that in any process of thought or memory there is not only a content thought of or remembered, but also a concomitant present content perceived. If this were not the case the doctrine of images could never have been so long held, even if it could have arisen. What, then, is the immediate content in thought if there are no "images" of the type conventionally described?

This question is answered definitely by those who have accepted what may be called briefly the "muscular theory of thought." The immediate content of thought is *muscular sensation*. "Sensation" is a multivalent term, as has been pointed out many times by philosophers and psychologists, so that we might as well rephrase this statement by saying that the immediate object in a thought is always a muscular contraction as "felt," i. e., as perceived through the action of sensory nerves running from the muscles themselves. This latter qualification is essential, since the contractions might also be seen or perceived through touch, as when the fingers of one hand are placed upon biceps of the other arm.

If the realities which have been miscalled "images" are all muscular, how is it that the current doctrine of images of various modalities—visual, auditory, gustatory, etc.—has grown up? In order to answer this question we must consider the way in which these muscular "images" arise.

All consciousness, it is now understood, is conditioned by *arc-reflexes*. The arc-reflex is the functional activity of a *reflex-arc*, a chain of neurons (nerve cells and their fibrous extensions) which begins at a "receptor," or sensory termination, (such as the delicate cells in the retina of the eye, which respond to light, or the hair cells in the inner ear which respond to sound vibrations, or the corpuscles in the skin which respond to pressure) and runs into the spinal cord, finally on up to the brain, then down the cord and out again, terminating in an "effector," namely, in a muscle or gland. Any sensory stimulation of sufficient intensity must, therefore, result ultimately in a modification of muscular or glandular activity, or both.

The glandular activity has no direct effect on the nervous system since there are no receptors in glands; but there are receptors (called "muscle spindles") in voluntary muscles, and when these are stimulated, by the contraction of the muscle, new reflexes are started over the arcs beginning in these spindles. These arcs may terminate in other muscles.

Perceptual consciousness and thought consciousness are both conditioned by reflexes over arcs terminating in voluntary muscles. This is a fact which has long been known. We may express it in a slightly different way by saying that muscular activity is a normal part of the essential physiological process which controls cognitive consciousness. This fact is sometimes, but incorrectly, referred to as the "motor power of consciousness." Feeling-consciousness, that is, the experience of pleasure, pain, desire, and similar contents, is probably conditioned by reflexes over arcs which terminate in glands, or in the involuntary muscles found in the stomach, intestines, and certain other parts of the body.

In some cases, the arcs are relatively fixed. In other cases, particularly in the case of arcs terminating in voluntary muscles, the connections of the neurons forming the chains may be varied. Just how the variation in the interconnection of neurons is brought about is not known, but it is made possible by the fact that each neuron in the nerve centers (brain and spinal cord) is in contact with many other neurons, and can thus discharge into one or another or several of them, as circumstances may determine. Once formed, however, an arc tends to persist; that is, if a certain sensory excitation, or group of excitations, has once resulted in a given set of muscular contractions, there is a tendency for the same excitation on its next occurrence to produce reflexes through the same arcs, and hence to result in the same set of contractions. This is the established *neural habit*. With repetition of the reflex, the habit becomes more strongly established. Thus it is that a given object, frequently exciting the sense organs, comes eventually to have a definite muscular response. This muscular response becomes, therefore, the symbol (or "image") of the object, and since it is the starting point of a new reflex, a series of such muscular contractions becomes, by the action of neural habit, bound together in a mechanical chain, so that in the absence of interfering stimulations, and eventually in spite of such, if one contraction occurs it will be succeeded in an automatic way by the other members of the chain.

This rechaining of reactions is the physiological side of the "association of ideas," for each reflex from voluntary muscle back to voluntary muscle is the condition not only of the perceptual consciousness of the contraction or image which starts it, but also the thought of the object which normally initiates the arc terminating in the contraction. The varying "attention" to the two things, now to the image and now to the thought-object or idea, is a matter of interrelation of the various arcs occurring simultaneously in the nervous system, and is too complicated for consideration here. Attention to the muscular process, usually called the "image," rather than to the external objects, is one form of the process known as *introspection*, which is the observation of images or of feelings.

We may now understand how the images may be misinterpreted, as they have been in the past, and supposed to be of visual, auditory and other kinds. The very fact that the nature of the image and of the process of introspection has not been understood has entailed impure introspection, the idea or ultimate thought object being confused with the image. Hence, if an idea is strongly visual in its character, it has been easy to neglect the actual image and assume that there is present a visual image or "copy" of the idea. Moreover, visual objects regularly call forth, as part of their reflex results, activity of the eye muscles, these muscles taking part, therefore, in the image of the object, and this in itself conduces to the interpretation of the image as visual. The contraction of the small muscles within the ear conduces likewise to the misinterpretation of the auditory object as an auditory image.

The muscles which take part in the furnishing of images include practically the whole of the voluntary system; i. e., the muscles attached to the skeleton, and certain others belonging to the visceral organs. In adult individuals the vocal muscles are, of course, most important, most of our thinking going on in terms of the articulatory movements which produce spoken words. Next in importance are the eye and inner ear muscles and the muscles of the arms and upper trunk. Even those of us who do not, like the Latin races, make the images apparent to others with the aid of our arms, still use these members slightly, thus complicating the images as we perceive them ourselves.

The muscular explanation of the process underlying thought activity is not merely of speculative interest, but is of practical importance to all the psychological sciences. Psychological investigations, like that of biology, have always been influenced by hypotheses, and always will be. In fact, it is doubtful if research in any line could proceed except under the guidance of pertinent hypotheses. There is evidence already that the muscular explanation of thought processes is to have a profound influence in shaping the research in a great many lines, and in supplying means of interpretation and criticism of what has already been accomplished. The problems of habit-formation, including learning in school, are having new light thrown on them, and new possibilities of investigation disclosed. The feelings and emotions, so important from the psychiatrist's point of view, but psychologically chapters in a closed book, are opening up. Even the will—the surd of psychology—becomes a possible subject of experiment in the light of the new doctrine of thought. Hypnosis and the so-called sub-conscious may be taken from the realm of the occult and put on a sound, although prosaic, psycho-physiological basis. Dreams, long material for the mystics, now the exploitabilia of the Freudians or neglected as meaningless jumbles, may be investigated as normal features of conscious life. Whatever may be the final form of the muscular theory, and whatever may be the final verdict upon it, it will inevitably have far-reaching consequences in the future of psychological investigation.

Parenty's Outflow Regulating Devices*

COMMON practises of disposal in this twentieth century of community wastes and factory effluents which not uncommonly find their way into streams, present certain problems since the water courses and lakes are very necessary for the supplies for domestic purposes.

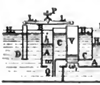


Fig. 1.—Section of regulator.

The absolute need of knowledge with reference to the purification of effluents and streams into which they flow has caused considerable activity in investigation and has been a fruitful field for invention.

Among the most recent of the methods of caring for the flow of effluents or streams receiving them is that presented by M. Parenty in a memoir read before the Academy of Sciences (Paris) on May 11th. He attacks the general problem in a number of ways, one of which is the regulation of a variable outflow. The effect of such regulation, or one phase of it at least, will be to spread the treatment of an intermittent effluent, or one which flows only during working hours, throughout the whole twenty-four hours, and may be applied either where it is desired to make the outflow uniform or where filters of one kind or another are to be employed. Following are the principal suggestions of the memoir.

Fig. 1 is a diagrammatic presentation of the regulator in section. A division wall lies between the receiving basin to the left and the outflow basin, treating tank or filter supply to the right. The two basins have different water-levels, as may be observed. Between these basins and forming a portion of the dividing walls is a chamber or lock, *A*, *A*. This has an inflow of fixed orifice, *ω*, and an outflow beyond the wall and into the basin, ω_1, which may be regulated.

The regulation of the outflow is effected by means of a flotation box, *C*, *C*, concentric with the valve, *V*, and moving it. The two are suspended from the arm of a balance, *L*, L_1. The flotation box is connected with the inflow reservoir and maintains the water level of the latter, the lock *A* being variable and somewhere between inflow and outflow levels. The submergence of the box, and with it the valve and the amount of outflow, will depend upon the difference in levels between the reservoir and the lock. This difference is so computed that the outflow will be uniform.

The inventor arranges for a correction to account for the different displacement of the box walls at different levels by a counterpoise, *D*, which is varied in the amount of its own submergence. Similarly the different displacements of the valve, *V*, in different positions are cared for by another counterpoise, *P*, above the pivots of the balance.

The other figures show some of the details and modifications under different circumstances. In all of them *R* is the storm water outlet to care for sudden flows which might cause derangements of the surfaces of the filtration beds. Fig. 2 is an application by Parenty of his principles to flushing basins and is adapted to small plants. The same general principle is maintained, but the flotation box here serves both for box and regulating valve. The inlet of fixed size, *ω*, is here in the bottom of the lock, *A*, which in the diagram is relatively much smaller than in Fig. 1, and the outflow is over the wall at *S*. The height of water in the box is the same as in the reservoir, being maintained there by means of the tube *U*, the tube *N* being a connection between the interior and the outer air.

In effluents the weak and intermittent flows are factors unfavorable to uniform distribution over filtering beds. The Parenty method of overcoming the difficulty is shown in Fig. 3. For the distribution over the bed, *I*, there is the familiar system of perforated tubes, *G*, or sprinkling nozzles, *H*, *H*, under pressure. The distributor that is recommended here is a siphon, *S*, which discharges into a movable bucket, *C*, on the arm of a lever and counterbalanced. The position of the bucket with reference to the fixed end of the siphon regulates the amount of flow.

Fig. 4 shows the principle again for outlets of large capacity. Here a metal disk, *L*, counterpoised, plays between the walls of the outlet. It regulates the outflow according to the pressure of the outflow upon it, which again is dependent upon the head of water in the reservoir. The flow may here be gaged by means of the index, as shown. Fig. 5, also for large outlets, presents the combination of this disk with the flotation box, the bottom of which forms the valve.

The figures show various other matters which are discussed in the original memoir. The tubes at the sides of Figs. 2 and 5 are piezometers, and *H* with its differentiating figure represents water levels whose differences form the important factor to the uniform outflow.

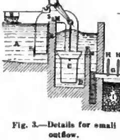


Fig. 3.—Details for small outflow.

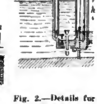
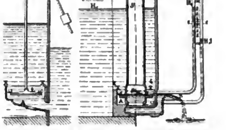


Fig. 2.—Details for small outflow.

For all these various forms Parenty claims that with small differences in level and in places where there is little room to spare, they effect their work with remarkable accuracy. They have recently been installed in the Port Said Nile filtration basins and also in various purification plants on the Calmette system in France, Belgium, Holland, and Indo-China.



Figs. 4 and 5.—Details for large outflow.

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* Translated from *Le Genie Civil.*

Poisoning Tree Scale

A CORRESPONDENT in *Science* relates the following rather startling experiment in killing tree scale by poisoning the sap of the tree. He says:

"I have in my ground a plant of Spanish broom about a dozen years old and with a trunk about four inches in diameter which has for several years been seriously infested by cottony cushion scale (*Icerya purchasi*). I have tried various sprays, have put scale-eating beetles on the tree, and at one time cut all the branches off and sprayed the trunk several times in the attempt to get permanently rid of this scale, but up to last winter it seemed that all attempts were in vain. In February of this year, when the broom was very thickly covered with the scale, I bored a ⅝-inch hole in the trunk to a depth of about three inches, filled the hole nearly full of crystals of potassic cyanide, and plugged it up. In two days the scale began to fall from the tree and in a few days all appeared dead. Others hatched and attacked the tree, but lasted only a short time, and the tree has since been free from scale and very vigorous.

"At the same time I bored a similar hole in an old peach tree which seemed to have passed its usefulness and put a like charge of potassic cyanide in it. The tree has since seemed more vigorous than before, and raised a fair crop of peaches. After feeding some of them to chickens and a rabbit with no apparent ill results, I ate some of the peaches, and could find nothing wrong with them. I have since put a similar charge of the cyanide in an orange tree with no apparent bad effect.

"It would seem from this experiment that it is possible in some kinds of trees, at least, to poison scale and sap-eating insects without injury to the tree. The method would seem to be especially adapted to killing various kinds of borers and insects which, like the pine beetles, burrow beneath the bark."

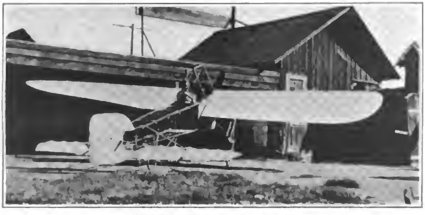
An American Aeroplane with Adjustable Wings

Improvements Necessary to Make Flying Safe, Practical and Commercial

By Carl Dienstbach

A device by which the incidence of the wings to the line of the propeller thrust and the axis of the fuselage may be varied at will during flight, strongly advocated by a writer in the SCIENTIFIC AMERICAN, and so brilliantly vindicated in France by the aeroplane "Paul Smith," was embodied still earlier in an American monoplane of the Blériot type, built by Ray Louis Matteson in California, and shown in the accompanying illustration.

A worm gear enables the angle of both wings to the fuselage to be changed simultaneously with a minimum of effort on the part of the pilot, and without disturbing the warping or the interaction between the two wings. The worm gear undoubtedly obviates two inherent difficulties of adjustable wings in providing an easy action and, being non-reversible, automatically locking the wings at any desired angle. Emergencies of flying, however, demand very quick action as well, and it must be possible to present the wings to the air at their steepest angle just an instant before touching the ground in landing, and this quite as suddenly as those of a sparrow are tilted in alighting on a twig. The wings must be swung with lightning speed into a position where their drift largely exceeds their lift, and a slow change of their incidence by the hand of the pilot working a worm gear would result in the very opposite effect of sending the machine skyward. It is therefore necessary either to provide a clutch by which the motor may be made to drive the worm gear for an instant at a very high speed, and release it just as quickly, and an automatic band brake to stop just as suddenly any further movement; or the worm gear must be replaced by a piston in a cylinder worked by compressed air from a tank, with suitable valve arrangements to instantly move it in either direction and lock it in any desired position. These mechanisms are so easy to provide that it would be a great pity if, first of all, an entirely novel and extremely useful way of landing like a bird, practically without a subsequent run, could not be soon reduced to practice by an American machine.



The Matteson adjustable wing monoplane.

The next task to be accomplished by an aeroplane with power adjustment of wing incidence would be to learn to practically stop in the air without falling, by shutting off power and "knocking" the wings into their steepest angle and just as suddenly reduce that angle only a little and running the motor at maximum power.

A really efficient execution of this maneuver calls indeed for a propeller whose pitch can be just as suddenly reduced to a maximum "standing pull"; and eventually, even for a variable speed drive between motor and propeller, as in an automobile.

No doubt many designers would be horrified by such "complications." But we see to-day that the path of practical improvement for such a rough-and-ready machine as a motor bicycle does not tend in the direction of simplifying but of so-called complicating, by adding clutch and change speed drive. Ten years ago the automobile was crammed with complications and designers are now busy adding electric starters and adjustable carbureters, etc., to facilitate their operation. In the same manner, adding so-called complications opens the only way of making the primitive aeroplanes of to-day more reliable, more safe, and consequently, at last, more practical and commercial. Nature shows us in flying birds the most efficient, economical, and practical kind of locomotion—only the migrating plover can enjoy the fruits of Alaska. But the flying machinery of birds, with the possibility of an infinite number of adjustments, is a hundred times more complicated than the proposed aeroplane. Nevertheless, just owing to the greater resourcefulness of mechanical arts as compared to inherent limitations in biological development, the proposed aeroplane will share the great privilege of birds over all present flying machines, in that they will not fall when an "airhole" suddenly destroys most of the relative motion between the air and the sustaining part of their advancing wings, or if it suddenly pours over them a wave of descending currents—incidents which aeroplanes are at present vainly trying to fend off by an inertia-forbidden sudden increase of speed. The proposed machine will instantly increase its lift *right on the spot* by a much steeper flying angle.

This of course calls for reserve power in the motor, or rather increased size of an adjustable pitch propeller with "two-speed drive" from the motor, but is no less possible than a bird's sudden increase of lift, right on the spot, by the vigorous flapping of the whole wing. Lilienthal has shown that such flapping is economical in power, and in the case of the bird, similarly reduces the needed extra effort. As for the mechanical devices named for the aeroplane, flapping is necessarily as much the tactics of Nature as the reciprocating lever action of legs and fins in running and swimming, but increasingly difficult to reproduce in a flying machine on any scale larger than a condor. To make stationary wings strong enough for the vicissitudes of flight taxes all mechanical resources, even in a medium-sized aeroplane. The Russian mammoth biplanes will, for good reasons, never attempt the arts of Pégoud.

All indications point to progress in the direction of making the medium and smaller-sized aeroplane as complicated and resourceful as a bird. There is an enlightening comparison to silence any protests against complicating. What must be more solid than a military rifle? Still, what a complicated machine serves now as a handle for the modern soldier's "pike," the bayonet, as compared to the simple tube of a hundred years ago! And this same small rifle has been easily turned into a "machine gun," whereas automatic cannon of larger caliber are difficult to make. Small pistols approached machine guns even with the invention of the first Colt revolver, and have now developed to well-nigh completely automatic action, although they must withstand much knocking about. The lesson for the small aeroplane is obvious. Fokker in Berlin recently constructed a tiny single-seater monoplane for "Pégoud-flights" with wings on which a photograph has shown a complete file of full-grown men standing without causing any distortion, and which has shown such marvelous flying qualities that its designer was officially honored.

Even as practical a flier and engineer as Helmuth Hirth has predicted machines with adjustable wings and reversible propellers in a book on his experiences, with a forecast into the future. Why has no prize been offered for realizing his proposal, instead of straining the present imperfect type to its limit in trying to increase size and radius of action?

Does all technical progress in flying have to depend on sensational tasks? Hirth predicted, also, high speed with small power; in other words, great radius of action for lightly loaded machines, due to refinement in design. If it was found necessary to equip the ocean-flying "America" with a third motor, it does not look as though a prize for crossing the Atlantic would bring about this much desired progress.

The aeroplane closely resembles the bird in limitations, and a sea-going machine should "feed" from the water like a gull or an albatross. In the light of what has been said above, one word suffices in pointing to the possibility of easily resting and raising an "America" on and from troubled waters by enormous adjustable two-drive propellers and adjustable wings; in other words, developing *great air lift at slow speed*. The "America" fell back into the water after the hydroplanes had lifted her.

This would permit safe alighting, restarting, and picking up fuel from steamers. If a very small fraction of the weight saved in fuel were devoted to a powerful searchlight (weights of aerial lights have recently been greatly reduced), making dead reckoning from the water feasible at night; and if, during periods of fog, a modified patent log were dragged behind on a piano wire, with a predetermined breaking point, there would be no difficulty to rendezvous with steamers.

The parallel between the direct lifting-flapping of birds and an aeroplane with a steep angle of attack holds good yet in another very important direction. In the last report of the Advisory Committee for the English government—now the most important contribution to the science publicly available, barring Eiffel's experiments—it was made clear that only with a high angle of attack is the aeroplane safe from insidious air chutes, and that for this reason fast machines are, contrary to theories, always flown slower when pilots encounter treacherous air conditions, just as soaring gulls can be seen to resort to flapping in gusts.

Thus, what is proposed here means only the *enlightened elaboration* of a policy already tried and proven by the best authorities, with this difference, that it was not derived from blind practice only, but from extensive study.

A fast modern machine thus operated, with the sole help of the elevator, becomes a very crude apparatus, ill adapted to its new function. Part of the wing finds itself in a current descending from the propeller. The fuselage is forced broadside on through the air, making its streamline form useless; and, worst of all, the small rudders and flaps, designed for normal speed, lose so much of their grip upon the air that they must be worked constantly near their critical angle, where further increase of effect becomes impossible, and the machine is in imminent danger of getting out of hand.

The small propeller designed for efficiency at high speed wastes as much power in slip as in starting, and the motor, even with throttle wide open, can no more run at maximum speed and power than in starting. Wilbur Wright told the writer as early as 1905, with his mystifying smile: "There is a propeller for everything, and the best propeller for normal flight is not the best propeller for starting." The obvious conclusion is that we need a propeller adjustable for different conditions. And yet, when a master designer like Chauvière exhibited it in large size, none seemed to grasp his purpose.

The proposed two-speed drive needs nothing like the range on an aeroplane that is required in a motorcycle. But when, with a maximum angle of attack for the wings, the greatest reduction of pitch for the enlarged propeller, which may be used without losing efficiency, does not yet allow the motor to run at maximum revolutions, the advisability of shifting gears becomes obvious. There are such simple, elementary, mechanical improvements needed in the present aeroplane that the constant expectations for something very far-fetched seem as pitiful as the wild fancies about the Wright machine while that was yet the famous mystery.

The awarding of one of the two prizes given in the recent safety contest in France to the "Paul Schmitt" was as just as that to its only successful rival who demonstrated so strikingly the beautiful mechanical train now available for any type of flying machine, but would have been yet more deserved if this mechanical improvement had not needlessly stopped short at adjustable wings, with Chauvière's adjustable propeller, ready to mount.

It must also be kept in mind that all these adjustmorals must be capable of being operated as quickly as a rudder is now swung to be available in emergencies, and that Blériot's simple "bell" must be developed into something almost as complicated and yet as quick and easy to handle as the stops of an organ.

With this we return to the meritorious American "Blériot" which furnished the occasion for this wide-scoped discussion. If, unlike the "Paul Schmidt," it has no record as yet of convincing tests, this is to be attributed to an error of the designer, who concentrated his efforts more on the attainment of automatic side control by a differential gear, automatically equalizing the pressure on self-adjusting warping wings. This would be possible if equilibrium could afford to neglect the *direction* of such pressures, but differences in direction of nearly 45 degrees may thus balance themselves in an extreme assumed case of a violent gust on the left and lull on the right, and this tends *ad absurdum* the belief that equilibrium could be maintained in this manner.

Pasteur's Words in Mankind's Struggle

In view of the present conflict it may be well to recall Pasteur's words, spoken in 1888. They were as follows: "Two opposing laws seem to me to be now in contest. The one, a law of blood and death, opening out each day new modes of destruction, forces the nations to be always ready for battle. The other, a law of peace, work, and health, whose only aim is to deliver man from the calamities which beset him. The one seeks violent conquests; the other the relief of mankind. The one places a single life above all victories; the other sacrifices hundreds of thousands of lives to the ambition of a single individual. The law of which we (men of science) are the instruments strives, even through the carnage, to cure the wounds due to the law of war. Treatment by our antiseptic methods may preserve the lives of thousands of soldiers. Which of these two laws will prevail, God only knows. But of this we may be sure, that science will obey the law of humaneness, and will always labor to enlarge the frontiers of life."

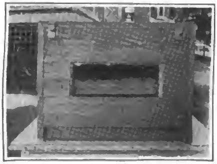
A Home Made Electric Incubator and Brooder

A Safe, Simple and Efficient Device for the Home Mechanic

By Charles B. Hayward

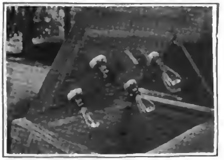
For the average "back-yard" chicken fancier, whose flock seldom exceeds fifty fowls, an incubator is a superfluity. But at times the hen is exasperatingly fickle and refuses to assume the seclusion of maternal duties just at the time when her services as a hatching machine are most in demand. An experience of this kind extending over two seasons, during which a small though very useful flock steadily diminished in numbers almost to the vanishing point, led to the construction of the incubator described here. There was no alternative but to buy chickens or to hatch them artificially, and as the latter was the more economical it was undertaken. However, the incubator problem was not one to be settled offhand, as the fire underwriters' rules prohibit the use of the lamp-heated type in insured buildings of any kind without special permission, and this permission is difficult to obtain, except for the high-priced machines. Having no desire to hatch chickens *à la* gentleman farmer at two to three dollars apiece, a high-priced incubator was out of the question. Moreover, the best lamp-heated types require more or less constant supervision, which is not desirable for the amateur whose only opportunity to look after such things is at the beginning and end of the day.

As the "attach it to any socket" electrical device does not call for special inspection on the part of the fire underwriters, it was decided to build an electric incubator. Contrary to the general impression, there is nothing mysterious about an incubator. It is merely a heat-proof box with provision for ventilation, heat-supply and the maintenance of the heat at a certain temperature—not lower than 100 deg. F. or higher than 105 deg. F., the mean sought for being 103 deg. F. at the upper surface of the eggs, to correspond to the temperature of the hen's body. Even less so is there any mystery about the electrical incubator; in fact, its construction and operation are simpler than the kerosene-heated type.



Complete incubator, closed, showing window and egg tray inside.

Interior and removable bottom. The dish is for water.



Detail of top connection of thermostat. One lamp removed to show contact.

The following description should enable anyone who is at all handy with tools to readily duplicate the electric incubator shown by the photographs. The cost of the materials complete is not quite five dollars, while a few evenings will suffice for its construction. The model shown by the illustrations has done excellent work, so that for those who wish to duplicate it as it stands, its dimensions are given. As a matter of fact, it could have been smaller and still have served its purpose equally well. This refers more particularly to its height.

Matched pine ceiling 3-8 inch thick was used, being screwed to 1 by 2-inch white pine framing, also screwed together. Screws were employed simply to avoid hammering; nails would do equally well though the screws made a stronger frame. This made a three-sided box, open at top, bottom and front, and with its frame plainly exposed inside. The space between the parts of the frame on each side was then filled with mineral wool and the frame covered with ceiling of the same kind as the outside, thus making a double-walled box with heat-insulating material in the walls. The front is of similar construction, except that it is hinged as a door and provided with a window, the details of its construction being quite as evident upon inspection of the picture as a description could possibly make them. The same framing material is employed with cross pieces inserted in addition to make a frame for the window. A slight recess is chiseled out of the frame to permit the glass to rest flush with it and the ceiling is then fastened down over it, the remainder of the door having been filled with mineral wool. The glass is double to prevent heat losses. At a point about on a level with the lower edge of the window two strips of the 1 by 2-inch framing are attached to the inner sides of the box to provide slides for the egg tray. This brings the eggs, thermometer and regulating device in plain view. The egg tray itself is made of ½ by 2-inch strips and ¼-inch mesh galvanized wire netting. The bottom tray is also of the same construction and is made removable for cleaning as the new arrivals are placed on this to dry off during the course of the hatch.

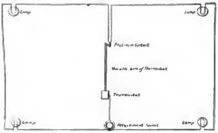


Diagram of wiring and thermostat.

The dimensions of the box are, height 17 inches, width and depth 22 inches. These are the outside dimensions, the inside being the same less the thickness of the walls. Through lack of foresight in planning the front construction it was necessary to make the egg tray somewhat smaller than would otherwise have been possible. As it stands it measures 15½ by 16 inches and has a capacity for between sixty and seventy hen eggs and forty to fifty duck eggs. This is ample for the amateur who keeps a small flock. The temptation to make or acquire a large incubator should be resisted as it must be borne in mind that hatching is only the first step, and unless given careful attention the mortality in a large flock of chicks will be high.

It will be apparent that this incubator could have been smaller without reducing its capacity, while a machine to hatch fifty eggs calls for a comparatively small box. "Hatch" in this connection is hardly correct. It should be maximum capacity, as there is always a substantial difference between the number of eggs put into the incubator and the number of chicks that hatch.

The mechanical details of the top construction are quite apparent. This top is double and has the mineral wool insulation, except at the edges, where it is of a single thickness in order to fit flush. It is not fastened in place in order to permit of removal for access to the lamps and thermostat, though for that matter experience in the use of the model illustrated showed this to be unnecessary, as they could be reached equally well through the large door, while a permanently fastened top would be more efficient where heat insulation is concerned.

So much for the mechanical construction. The electrical end is equally simple. The actual heaters themselves are nothing more or less than 16 candle power carbon filament incandescent lamps, of which four are employed. These are wired in two groups, the two lamps in each group being in series with one another, both groups being directly controlled by the thermostat. Their arrangement with relation to the latter will be plain upon reference to the wiring diagram shown. From one

Details of heater and thermostat, one lamp removed to show contact arm.

side of the attachment socket, which is located centrally in the top, two wires are led in opposite directions to the two groups of lamps.

This wire is No. 14 "single braid" or rubber covered wire as used for incandescent lighting, and costs about two cents a foot retail. Connection is made at one side of the lamp, and another piece of wire employed for connecting the opposite sides of the two lamps, as shown by the diagram. This leaves open one connection on each of the two lamps belonging to the different groups. From these a wire is carried to the contact plate of the thermostat. The lamps are mounted in ordinary keyless sockets, costing about twenty-five cents each, directly on the inner face of the top of the incubator. By employing what are known as "sign receptacles" or some similar form of countersunk socket, two to three inches could have been saved in the height of the machine.

All the wiring and connections were carried between the two faces of the double top, and the distances are so short that no fastenings were necessary. After completing the connections the remaining space was filled with mineral wool and sealed up, holes having previously been bored and connecting wires carried through them for the thermostat. Upon the latter naturally depends the measure of success to be expected from the machine. The heat controlling device consists of an ether filled light sheet copper diaphragm of corrugated section such as is almost universally employed by incubator manufacturers. To increase its range and sensitiveness two of these diaphragms are coupled together. The device complete as shown was purchased from an incubator parts maker for $1.10.

As received it has a brass wire arm, ordinarily designed to carry a small disk or damper intended to open or close the vent in a lamp chimney. This damper must be discarded and an electrical contact substituted. Platinum is the best material for such contacts, as an insulating film of oxide rapidly forms on almost every other material, and such contacts caused the only trouble experienced with the incubator.

A carbon point to copper, direct copper and silver contacts were tried with poor results, as they wasted and fouled quickly, and were finally discarded for platinum, which was absolutely reliable.

By the aid of an obliging dentist two pieces of sheet platinum about ⅛ inch square were obtained, and one of the pieces soldered to each of the contacts. Since then no trouble whatever has been experienced, and the regulation of the machine is so reliable that one almost gets the impression that the thermometer has "gone dead" with the mercury glued to the 103 deg. line. Except when the door is opened it would not vary so much as a fraction of a degree for twenty-four hours, regardless of changes in the outside temperature. Adjustment is made by means of a regulating screw on the thermostat which alters the distance between the disks and the lever, thus causing the latter to rise from the contact sooner or later. The machine reaches the proper temperature within two to three hours of being set, and from that time on the lamps never burn continuously, except for a few minutes after the door has been opened. They flash off and on intermittently, one second on, three to four seconds off, with such regularity as to give an excellent imitation of a flashing lighthouse. This serves to reduce the cost of operation, as the current is on for less than fifty per cent of the time, while wiring the lamps in series also tends to reduce the bill. In spite of both these factors, the cost of operation is high as compared with kerosene, the bill for running it 28 days with duck eggs being approximately $2.25 (rate 15 cents per kilowatt hour).

A slight amount of trouble was experienced with the regulation after a few days, due to the crude machine work of the thermostat. The regulating screw was such a poor fit that the vibration of surrounding objects caused by a person walking near by would shake it up or down with a corresponding variation in the temperature. This was not serious, as it was never more than a degree one way or the other, and usually only a fraction, but it was overcome by tinning the thread of the brass screw with soft solder, thus making it a tighter fit. Pieces of cloth or felt were put in the bottom tray during the hatch to prevent drafts reaching the eggs.

Hatching is only a small part of chicken raising, and a brooder is indispensable to take care of the newcomers as soon as they are able to get around. A brooder 24 by 24 inches, having ample capacity for the maximum number of chicks that the incubator could possibly hatch, was constructed for about $1.75. A frame this size was made, covered on one side with the same ceiling as the incubator, and four "sign receptacles" or countersunk sockets screwed to it. These were connected in two series groups with an attachment socket, no regulating device being necessary. The space was filled with mineral wool and the under side ceiled, this making four sockets facing downward and one upward. Four 5-inch legs of 1 by 2 stuff were then screwed to it at the corners, and old strips of flannel, woolen rags and similar material that came handy about the house were tacked along the top edge completely around. With a hole bored through the two layers of the top for insertion of a brooder thermometer, this completed a simple and effective hover. Four 16 candle-power carbon filament lamps provided the heat. It was seldom necessary to burn but two of the lamps (one series) to maintain the temperature in this hover at 90 deg. F., and for a considerable part of the time the current was off altogether. Only two of the hatch were lost in the brooder during their two weeks stay in it, and as they were not up to the standard of the others, it proved quite as successful as the incubator.

New Experiments of M. Eiffel*

Further Light on Aeroplane Problems

By A. J. A. Delaunay

M. EIFFEL has just published a report on the first experiments made at his new Aeronautical Laboratory at Auteuil. This book is much more important than the previous one, giving the results of the experiments conducted at the original laboratory near the Eiffel Tower. It consists, in fact, of two volumes, one of about 400 pages containing explanations of the experiments and their application to various cases, the other consisting of the curves showing the results of the experiments.

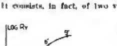


FIG 1

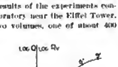


FIG 2

It is impossible to give here a full account of this work, but we will take the general results and discuss them, chiefly where they can be compared with the results shown in the *Blue Book* recently published.

M. Eiffel still uses the same kind of apparatus as in his previous experiments. Instead of a wind tunnel similar to that in existence at the N. P. L. he cuts his channel in two parts and between them places a large room in which the experiments are conducted. This method is quite accurate: by measuring the velocity of the air in the air current, the difference between the velocity in a point in the air current and the mean velocity has been found (in the part where the models are placed) not to exceed on the average 0.5 per cent of the speed (the greatest difference found is 1.1 per cent).

Two cylindrical channels are provided: the larger one is two meters (6 feet 7 inches) in diameter, and the air passes through it with a velocity which can reach 32 meters per second (105 feet per second, or about 71.5 miles per hour), while the other is only one meter in diameter, but the air passing through it reaches a velocity of 40 meters per second (127 feet per second, or nearly 90 miles per hour).

The weighing appliances used enable the values of the coefficients K_y (lift for an area of 1 square meter at a speed of 1 meter per second), K_x (drift under the same conditions), the position of the center of pressure and the positive or negative pressure on the aerofoils to be determined.

In the reports of his previous experiments, M. Eiffel represented his measurements on aerofoils by a certain curve which he called a "polar curve." This curve is drawn by plotting the values of K_y against the values of K_x; but chiefly when K_x is very small (when the incidence is that of normal flight) the shape of the curve makes it difficult to compare two different wings. In the new report M. Eiffel keeps the general shape of the curve, but makes it more easy to read by plotting K_y against $5K_x$. Thus the difference between the shape of the curve for two wings appears more clearly.

In addition to this method, and chiefly in order to represent the measurements on models of complete machines, one of M. Eiffel's engineers, M. Rith, devised a new type of curve, called the "logarithmic polar curve," which makes it easy to solve all the usual problems which the aeronautical engineer wants to investigate when he intends to alter an existing machine.

Let R_r be the drift and R_v the lift on a model when the velocity of the wind is 10 meters per second, and R^x and R_y the drift and lift on the full scale machine when the speed of the machine is 1 meter per second.[1]

Now let P be the useful power necessary for displacing the machine of which Q is the weight, and the speed V, then

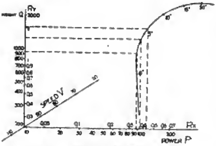


FIG 3 LOGARITHMIC POLAR CURVE OF DORAND MACHINE

$$P = R_x V^3$$

$$Q = R_y V^2$$

$$(1)\ \begin{cases}\log. R_x = \log. P - 3 \log. V\\ \log. R_y = \log. Q - 2 \log. V.\end{cases}$$

If now we are plotting log. R_y against log. R_x, the equations (1) mean that an abscissa log. R_x may be considered as being the resultant of log. P and -3 log. V, while the ordinate log. R_y may be considered as being the resultant of log. Q and -2 log. V.

But then the resultant of the two components -3 log. V and -2 log. V makes with the axis of log. R_x a constant angle, the tangent of which is 2/3 and its length is

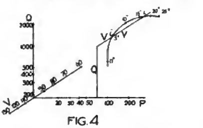


FIG. 4

$$\sqrt{3^2 + 2^2}\ \log. V = \sqrt{13}\ \log. V.$$

Then if we require a point on the curve, we can read it by taking the resultant of three components of which the directions are known and the lengths are proportional to log. P, log. V, and log. Q, and this point will represent the machine weighing Q kilogrammes flying at V meters per second with a useful power P.

The directions of the three axes log. P, log. Q, and log. V being constant, the point reached on the curve is always the same when P, Q, and V are constant, whichever is used in the first place.

We see that the "logarithmic polar curve" gives us at the same time the lift R_y, the drift R_x, the weight Q, the power P, and the speed V.

Furthermore, in the equation (2)

$$\text{Log. } R_x = \log. P - 3 \log. V,$$

P is in kilogrammeters 1/75 of a metric horse-power, which differs only slightly from the English horse-power) and V is in meters per second. If P' be the power in horse-power and V' the speed in kilometers per hour, we shall have

$$P = 75\ P'$$

$$V = \frac{V'}{3.6}$$

and then

$$\text{Log. } R_x = \log. 75 + \log. P' - (3 \log. V' + 3 \log. 3.6).$$

This means that by changing the origin of co-ordinates we can use the amount of horse-power and the speed in kilometers per hour directly.[2]

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* Reproduced from *Aeronautics.*

[1] If the scale of the model be 1/10 full size, and if we admit that the ratio of the lifts and drifts be in that case 1/100, we shall have $R_x = 100\,\frac{R_r}{100} = R_r$ and $R_y = R_v$.

And as there are many figures that are useless, since, for example, we shall not have to design an aeroplane weighing 10 kilogrammes flying at a speed of 1 kilometer per hour, we can change again the origin of the co-ordinates and use only the part of the axes which represent the real cases.

Then we get a curve similar to the one shown here when the weights are varying from 200 to 2,000 kilogrammes, the power from 50 horse-power upward, the speeds below or above 100 kilometers according to the direction of the component V.

These curves enable an engineer to solve immediately a great many practical problems; we shall see below some of them.

1. The weight and the useful horse-power of the machine being known, what will be the speed and the angle of incidence?

Let $P = 70$ and $Q = 1{,}000$ (see Fig. 4).

We find immediately[3]

$i =$ 4.5 degrees $V = 86$ k.p.h.
$i =$ 17.5 degrees $V = 60$ k.p.h.

2. The weight being 700 kilogrammes, we wish to fly at 80 kilometers per hour. What will be the necessary power?

We find $P = 52$ horse-power and $i = 3$ degrees (see Fig. 5).

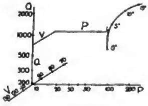

FIG. 5

3. We have $P = 60$ horse-power and we wish to reach a speed of 80 kilometers per hour. What must the weight of the machine be?

We find $Q = 930$ kilogrammes, $i = 5.2$ degrees (see Fig. 6).

4. What is the greatest speed attainable with a given horse-power?

The equation $P = R_x V^3$ shows that R_x must be as small as possible, which is the case when the ordinate Q is a tangent to the curve (see Fig. 7).

5. What is the greatest possible weight with a fixed speed? (Fig. 8.)

This is reached when P is tangent to the curve, when R_y is maximum.

6. The weight being fixed, what is the minimum horse-power necessary?

If we mark Q on the axis of the ordinates and draw a line parallel to the axis of P, the P will be minimum when the V component is drawn as much as possible toward the left, namely, will be a tangent to the curve.[4]

7. What is the smallest propeller thrust F which renders flight possible, when the weight is given? (Fig. 9.)

We have

$$\frac{F}{Q} = \frac{R_x}{R_y}$$

$$\text{Log.}\ \frac{F}{Q} = \text{log.}\ R_x - \text{log.}\ R_y$$

$$\text{Log.}\ R' - \text{log.}\ R_x = 0$$

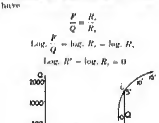

FIG. 6

is a straight line N of which the angle with the axis is 45 degrees.

For a given value of $\frac{F}{Q}$ the two corresponding points on the curve will stand on a line parallel to N, and the minimum value will be reached when the parallel is a tangent to the curve.[5]

Various Experiments.—M. Eiffel has made a number of experiments in order to ascertain the influence of changing the velocity of the wind. While the resistance coefficient of a circular plane is nearly constant when

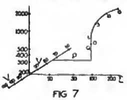

FIG 7

the velocity changes from 4 to 30 meters per second in the case of spheres, cylinders, streamlined struts and dirigible bodies, the head-resistance coefficient decreases when the speed increases. In the case of spheres or cylinders a limit value seems to be reached when the speed is about 20 to 24 meters per second, but this limit changes with the dimensions of the tested bodies.[6] In the case of cylinders it must be noted that, in accordance with Dr. Thurston's experiments, the resistance decreases when the length of the cylinder increases.

Regarding streamline bodies, the limit value of the resistance coefficient was not reached when the speed was 40 meters per second (89 miles per hour). It may be noted that some experiments show the influence of skin friction, since when two bodies have the same diameter, the same fore and aft shapes, and differ only in the length of the cylindrical part, the smaller this length, the smaller is the head resistance.

M. Eiffel has made some new experiments regarding the influence of speed on the resistance of wires: in the case of piano wires the speed does not seem to be of great importance. The resistance of cables at small speeds is less than the resistance at high speeds, and a small cable has the same head resistance as a piano wire; but the resistance increases with the diameter and for cables of ⅛ inch K would be about 0.072.

Aerofoils.—One of the most important questions relating to the resistance of aerofoils is the possibility of an increase in efficiency when the size and speed increase. In the Technical Report for 1912-1913 it is assumed that it is indifferent to increase the size or to increase the speed of a model. In the August issue I gave the results of comparative experiments at St. Cyr and M. Eiffel's Laboratories, showing the influence of actual size. M. Eiffel tested several wings at different speeds, and his results are as follows:

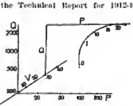

FIG 8

The aerofoil No. 30 was tested at 10, 20, 30, and 40 meters per second. The measurements gave figures which did not differ by more than 2 or 3 per cent, which differences can be imputed to errors in readings. Consequently, the ratio Lift to Drift is nearly constant for that shape of aerofoil. With the aerofoil No. 32, which is very slightly double curved, there was noticed, on the contrary, an increase in efficiency. The Lift coefficient was not altered, but the Drift coefficient was decreased and the efficiency increased at high speeds for the small angles of incidence. The reverse occurred when the angle of incidence was larger than 11 degrees as shown by the accompanying table.

Speed in met. per sec.	Angles of incidence						
	0°	3°	6°	9°	12°	15°	
10 20 30	7·6 14·2 15·06	18·35 18·1 18·1	13·1 10·1 10·4	11 11·6 11·0	8·75 8·7 8·8	6·15 6·15 6	Lift / Drift

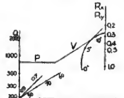

FIG 9

The great difference between these two cases shows how difficult it is to generalize the results obtained on one type of aerofoil.

In other experiments M. Eiffel tested aerofoils which were of varying thicknesses; in one case the bottom curve was not changed, while in another the middle curve was kept constant. These tests, together with some on special types of thick aerofoils, made it clear that in the case of thick aerofoils the resistance was greatly modified when the speed was changed, and it is sometimes possible to get, for certain angles of incidence, two values of the lift coefficient. At any rate, these experiments seem to prove that it is better in a set of aerofoil sections for use on a propeller, to keep the middle curve constant rather than the bottom curve.

From a similar series of experiments on the influence of aspect ratio, M. Eiffel concludes that by diminishing the aspect ratio the lift coefficients are decreased and the drift coefficients are increased. But it must not be concluded that the same value of aspect ratio is the best for every type of wing; with the aerofoil No. 31 the best tested aspect ratio was 6, but for another type of camber it has been found that the best aspect ratio, when K_y is less than 0.3, is 5.

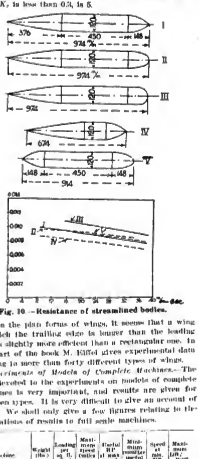

Fig. 10.—Resistance of streamlined bodies.

As in the plan forms of wings, it seems that a wing in which the trailing edge is longer than the leading edge is slightly more efficient than a rectangular one. In this part of the book M. Eiffel gives experimental data relating to more than forty different types of wings.

Experiments of Models of Complete Machines.—The part devoted to the experiments on models of complete machines is very important, and results are given for nineteen types. It is very difficult to give an account of them. We shall only give a few figures relating to the applications of results to full scale machines.

Machine	Weight (lbs.)	Loading per sq. ft. (lbs.)	Maximum speed (miles per hour).	Useful HP at max speed	Minimum possible useful HP	Speed at min. HP	Maximum Lift/Drift.
MONOPLANES							
Drzewiecki	1575	5·6	66·5	80	43	57	6·15
Blériot	1600	4·9	61·5	35	26	47	8·3
[illegible] ..	880	5·4	50	35	23	40	8
Morane ([illegible]) ..	1060	11·1	52	60	23	40	9·0
Do. (two-seater)	1210	7·46	51	50	20	50	9·9
Paris	1100	6·4	47	30	19	40	8·5
Tatin	396	4·1	53	7·5	6·11	43·0	7·0
Bristol	1700	5·45	73	70	24	54·5	6·2
BIPLANES							
Farman (1909) ..	1690	3·5	43·5	45	37	37	4·8
M. Farman (mono)	1610	3·4	48	50	30	34	4·4
do. (two-seater)	1700	2·85	44·7	50	40	36	4·4
Breguet (two-seat)	1980	5·1	59	60	30	49·5	7·05
do. (three-seat)	2300	6·15	60·8	80	48	47·5	7·46
SEAPLANES							
Collier-Janson	7050	5·4	50·3	275	235	51	8·2
Breguet (Marseillaise) ..	2960	9·5	77·5	80	60	50	8
Nieuport ..	1670	7·75	62·5	80	42	40	6
Pateras Pescara	6150	8	67	200	152	51·5	5·6
Alvarez et de Cerda	1200	4·05	60·2	35	24	43·5	7
Max Oertz ..	2350	5·1	62	70	48	60	6·1

The models were also tested with a view to ascertaining their static equilibrium, namely, to know if, in case of a change of incidence, there was produced a couple bringing the machine to its normal attitude; with the exception of the Maurice Farman, in which the righting couple is very small, and the Tatin, which was not tested, all the machines were found to be stable in this respect.

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[2] It would be quite as easy to use the power in horse-power and the speed in miles per hour.

[3] We find here the two speeds to which I have referred in my previous article on "Safe Landing." If it were taken into account that the efficiency of the propeller is not the same at both speeds, we should have another value for the low speed, which would be obtained by following the dotted lines AD.

[4] Here we have the "neutral attitude" of which I spoke in the July number of *Aeronautics*.

[5] It must not be forgotten that if it is required to go from one point to another (in fine weather) as economically as possible, it is necessary to fly so that F is minimum.

[6] The results on spheres are in accordance with the results of experiments made by Capt. Costanzi in water (*Rendiconti delle esperimenti della Brigata Specialista*) and the Aeronautical Laboratory of St. Cyr in air. In all these cases there is a drop in the resistance for a certain value of the speed, which value depends on the diameter of the sphere. Lord Rayleigh pointed out that in this case the product vd should be nearly constant, but this is not shown by the above experimental results.

Treatment room of an English hospital train.

Pharmacy room of the converted ambulance train.

The Care of the Wounded

A Vast and Complicated System of Which Little is Heard

The first object of an army in war is to disperse or destroy the enemy, but a correlative duty is the care of its own men when wounded or otherwise incapacitated for service; and this involves a very extensive and carefully systematized service that has been as thoroughly studied and developed as the maneuvers of the fighting men. Although the results of the modern systems of handling and caring for the wounded must necessarily, to a great extent, depend comparatively on the differing local conditions, the work now being done is in every respect a vast improvement over that of previous wars, owing both to experience gained and to constant improvements in medical and surgical knowledge.

In the case of a battle, the first proceeding is to locate the injured men on the field, and a late number of the *Umschau* contains an interesting plea for the use of trained dogs in the search for wounded after a battle. The claim is that thereby great mortality would be prevented, as the dogs could find the badly wounded lying in thickets or obscure places, thus bringing speedy aid to helpless men who might otherwise die in agony from neglect. The article is by a German cavalry captain named von Stephanitz, and the curious fact is that it was written just before the mobilization of the German army. The outbreak of the war leads the author in a note to state that such dogs are already being tested by actual use and to urge contributions for a further supply of them.

Former wars have shown that wounded who are unable to reach the field hospitals themselves, or who cannot be brought there, often exert their last strength to reach shelter of some kind in the open, in order to escape further wounds or the danger of being ridden or driven over. Others of the severely wounded remain lying on the spot where the shot struck them, and these spots are often not easily found, especially in approaching twilight, and, above all, at night. For, although during a battle the wounded are given such care as is possible by the ambulance corps, yet the carrying of the wounded to the field hospitals from the district under fire is generally only possible after the firing has ceased, nor can a systematic search of the battle-field begin until then. And yet all wounded men ought to be found and carried where they can receive surgical aid as quickly as possible.

Even should the ambulance corps and its assistants exert themselves to the utmost to accomplish their task, nevertheless every region contains spots where wounded could be overlooked, and unfortunately are overlooked. This is proved by the number of "missing" in the reports of losses. Search should be made in fields of standing grain, in ditches, behind hedges and bushes, or in spots where the searchlight cannot penetrate or throws heavy shadows; above all, there is danger of such being overlooked in the undergrowth of woodland.

The author in setting forth his views, which deserve all the more attention as coming from a military man, continues:

"Searching has its restrictions, as has already been shown, in the limitations of the human perceptive faculty, above all in those of the eye, and under certain conditions also of the ear.

"But there is a willing assistant with keen senses, the qualities and perceptions of which mankind has known how to use for thousands of years—the dog. The use of the dog for charitable work is nothing new, as is shown by the well-known dogs of the Hospice of St. Bernard. Even police-dogs in their night searches often scent out helpless people or drunkards in obscure spots off from the roads. For finding the wounded the use of dogs, ambulance-dogs, is of much importance. The dog's chief organs of sense, the nose and ear, supplement and complete those of the detail for finding the wounded; the scent for the game is in the blood of some breeds, and can be developed in others by suitable training. A dog's build enables it to race ahead of the searchers, especially on reaching thickets which the men can

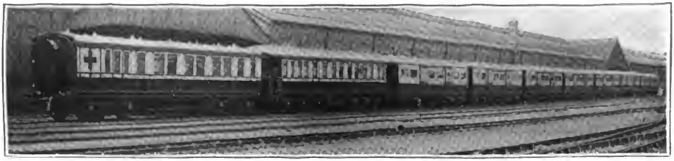
[illegible]

Major Richardson of the British army and two of the famous hounds that he has trained for Red Cross work on the battlefield.

Major Richardson is well known for having introduced the dog into the police service

View down the center of ward car of an English military ambulance train, showing fixed berths and cots.

In the center of each train is a pharmacy car with treatment room, office, and all necessary supplies.



One of the four new railway ambulance trains constructed by the London & North Western Railroad Company for the transportation of wounded soldiers in England.

The vehicles were taken from mainline traffic and altered for hospital use in thirty hours.

German Red Cross prisoners.

Red Cross nurses on the French side.

Wounded French and Germans in a Belgian church used as a hospital.

A wounded Turco being carried to the ambulance.

Photo by [illegible]

German prisoners in front of the church of Neufmontiers.

A wounded Turco supported by his comrades.

The first field dressing packet.

The field dressing packet is carried in a left-hand pocket in the lining of the coat. On the outside of the wrapper are full directions for use.

Identification disk worn on active service.

The identification disk is served out to all soldiers in the British army at the beginning of active service. It is made of aluminium, and is worn by a cord round the neck. On the disk are punched in raised letters the wearer's name, regiment, official number, and religion.

The emergency rations packet.

This packet is carried in a right-hand pocket in the lining of the coat, and is ready to hand when needed. The packet is small and compact and takes up very little room.

scarcely enter. While thus going on ahead, its quick ear hears the breathing of a wounded soldier, or a puff of wind carries to it the scent of someone in a lonely spot."

The advantages resulting from the use of ambulance-dogs have been long known. As far back as 1893 a society to promote their use was formed in Germany, and similar societies were founded in Belgium, Denmark, France, England, Italy, the Netherlands, and Sweden. To some degree official efforts were made in these countries to encourage the maintenance of such dogs, but these efforts did not go much beyond good intentions and mere beginnings, because the ambulance-dog, while a necessity in war, is of no use in peace. That is, these dogs cannot be kept in sufficient number for real use in warfare without a disproportionate outlay in labor and cost of upkeep.

There is in Germany a "Society for German Sheep-Dogs," which is the largest amateur breeding association in that country. This association was the first to urge the use of police-dogs, and since the movement for police-dogs has grown stronger, the society has constantly insisted that the police-dog service has solved the problem of maintaining a breed of dogs suitable in war for ambulance-dogs. Among the breeds inspected for this work were the dogs used by the gendarmes, those used by the officials of the custom-houses at the frontiers, those kept by foresters, and by the country police. These were dogs accustomed to all kinds of weather, to long runs, and work in the open in finding the game. After experiments had been tried with these, the "German Society for Ambulance-Dogs" resolved to take up the work also and to breed a supply of ambulance-dogs, as well as to train leaders for these dogs in war time. Any further steps in the matter would depend on the attitude maintained by the proper authorities.

Naturally neither all dogs nor all breeds of dogs can be used with an ambulance. The only suitable ones are hardy dogs inured to all kinds of exposure, of a build capable of prolonged exertion. Consequently, there only remain the four breeds from which the police-dogs are chosen: German sheep-dogs, the Dobermann terrier, the Airedale terrier, and the Rottweiler. Of these four breeds the sheep-dog is by far the most numerous.

In winding up his earnest appeal for a good supply of such dogs, the captain says:

"Naturally, the dogs must be completely bare during the search. All equipment, even a collar, might only expose them to the danger of being caught and unable to push forward when working their way through a heavy thicket. The fine-sounding suggestions that ambulance-dogs should be equipped with the Red Cross, bottles containing refreshing drinks, bandages, notebooks, little bells, or even lanterns, are mere puerilities, worthless, if not dangerous, in actual use. The ambulance dog should have nothing to do but to find, to find as quickly as possible, in order that the wounded thus found may soon have human aid and care."

The cuts on this page are from *The Sphere*

HOW MANY WOUNDED MUST BE PROVIDED FOR?

In developing any intelligent or practical system for handling the wounded, as well as those incapacitated by sickness, it is necessary to know how many patients will require treatment, and furthermore, for what periods of time; for some will need but a few minutes attention on the field, while others will require long and careful treatment. How these questions are determined is told by Major F. A. Symons, M.B., R.A.M.C., in the September issue of *Blackwood's Magazine*.

"In preparing for the treatment of the wounded one must have some idea as to what the likely requirements are to be. How many wounded are to be expected from each engagement? To the uninitiated this question seems unanswerable. In a sense, of course, it is unanswerable. And yet it is upon definite figures of probabilities that all the regulations of the army in the field are based.

"Let us take an army division as our unit for study. A division in war comprises some 18,000 men. Statistics, based on all great previous wars, point to certain average facts, which may be summed up as follows:

"Out of this 18,000 men only about three fifths will be actually engaged with the enemy. The remainder, employed in various non-fighting capacities for the moment, become for the purposes of calculation a negligible quantity. Say that 10,000 men are engaged. Of these, 10 per cent must be expected to become casualties—i. e., 1,000. Of this 1,000, 20 per cent will be killed. This leaves us 800 to deal with. Of this 800, 20 per cent will be able to walk to what is called the Divisional Collecting Station. There, having received what surgical aid they require, they will remain until the end of the engagement, and then return for the remainder of their required treatment to their units; 640 are therefore left for admission to hospital; 60 per cent (of the 800) can be carried in the ambulance wagons, sitting up; 15 per cent will require lying-down accommodation; and 5 per cent will be unfit to be moved from the place where they fell.

"It will readily be seen, therefore, that the Army Medical Service in the field starts forth with a fairly shrewd idea as to what it may be called upon to face."

Different systems prevail in different countries, but the writer goes on to describe the British organization, which represents the methods followed generally:

"Let us start with the battalion of infantry. Each company boasts of two 'regimental stretcher-bearers,' who, having been trained in first-aid work, carry a stretcher. At the beginning of an action these bearers, under the command of the medical officer attached to

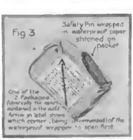
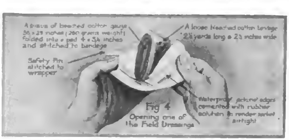


Fig 3
Safety Pin wrapped in waterproof paper stitched on packet
One of the 2 Packages
Arrow on label shows which corner, being [illegible] of the waterproof wrapper to open first

One of the two packages in the outfit.

Both packages of dressings are identical. The arrow on the label shows which corner of the waterproof wrapper is to be opened first. The corners are securely cemented with rubber solution.


A piece of bleached cotton gauze 36 x 23 inches (200 grains weight) folded into a pad 4 x 3½ inches and stitched to bandage
A loose bleached cotton bandage 2½ yards long x 2½ inches wide
Safety Pin stitched to wrapper
Waterproof jacket edges cemented with rubber solution to render packet airtight
Fig 4
Opening one of the Field Dressings

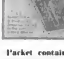
Opening one of the field dressings contained in the packet.

The field dressings contained in the first-aid packets have a waterproof outside covering with the edges cemented with rubber solution to render the packet tight. Stitched to the wrapper is a safety pin for use when bandaging wounds. Inside the wrapper is a loose bleached cotton bandage 2½ yards long and 2½ inches wide, and a piece of bleached cotton gauze folded into a pad and stitched to the bandage.

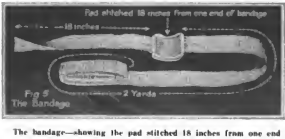
Fig 6
Applying the First Field Dressing

Applying the first field dressing to a wound.

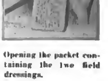
The pad is applied over the wound, and then the bandage is wrapped firmly and evenly, according to the directions given, and the ends secured by the accompanying safety pins.



Packet containing field dressings included in the outfit of every soldier.



The bandage—showing the pad stitched 18 inches from one end of the bandage.



Opening the packet containing the two field dressings.

the battalion, fall to the rear, and are located as the medical officer sees fit. A soldier falls, wounded. First-aid is at once applied by the bearers, and the wounded man carried to the shelter of a rock, ditch, or trees, close at hand. If the wound is particularly serious the medical officer intervenes. The latter cannot, however, be everywhere at once, and the battalion, in open order, may cover almost a mile of country."

In this connection attention may be directed to first-aid field dressing and emergency packets that in some form are in use by most European armies, and are ready for instant use when a man is wounded, and will save much suffering, and many lives that would be sacrificed if the injured had to await the arrival of a surgeon. The packets used in the English army are fully illustrated and described in the accompanying cuts.

It will be noted that this is purely regimental work, and not directly attached to the regular ambulance service, which now takes up its work.

"There are three brigades in a division, and each of these is provided with one field ambulance, consisting of three sections, which may either work together or over separate zones. Each section is again subdivided into a bearer and tent subdivision. In action one tent subdivision is usually pushed forward as near the fighting line as safety will permit, in order to establish a dressing station.

"From this station the bearer subdivisions, equipped with stretchers and supported by ambulance wagons, start forth to search for wounded. In order to insure that no wounded are missed, and also for the sake of avoiding overlapping, each bearer subdivision is appointed to a definite area of the fighting zone, marked out on the map."

From the regimental aid posts, previously mentioned, the bearers collect and convey the wounded to the "collection station," where the ambulances have been assembled, by which all are taken to the dressing station. Here the wounds requiring it are dressed afresh, and urgent minor operations performed. It will be found here that many men require no further treatment except what they can obtain at their regiments, to which they are at once returned. The others are loaded into the ambulances, or other conveyances, and taken to the rear, out of shell fire, where a full tent division of the field ambulance will be found. This, however, is a mobile unit that is required to follow up the army closely, and as it may be required to move at any moment the wounded are not kept there longer than necessary. There is, however, plenty of food and medical necessaries.

From this field station the wounded are rapidly transferred to the nearest railroad, and thence to various stationary hospitals, or to the base hospital, according to the length of time the patient will require treatment. The number of these transfers will depend on the distance of the front from the base, and the facilities for transportation; but it will be seen that a constant sorting process is operating to return men slightly injured to their commands as quickly as possible, thus relieving pressure on the hospitals, and only serious cases reach the base.

This writer also notes the fact that the British army now has a "sanitary service" under skilled officers, which is expected to counteract the ravages of disease that have been so fatal to armies in the past. This service will include the inoculation of the men against typhoid and enteric fever, a method that has been proved most effective in India, the South African war and elsewhere.

OPEN AIR HOSPITALS.

The subject of caring for the wounded has raised the question of the efficiency of the primitive stations denominated as hospitals, and in this connection an article on "Open Air Hospitals in War Time," by Prof. Robert Saundby, of the University of Birmingham, published in a recent issue of *The Lancet*, is most timely and interesting. The professor's summing up of facts and observations that have been well known for years, but for some reason generally ignored, is as follows:

"The usefulness of hospitals is almost in inverse proportion to their architectural merits and our exaggerated notion of 'comfort' is inconsistent with healthy surroundings. Draughts of air, low atmospheric temperature, and dampness are not the disease-bearing agencies they were once supposed to be, while bad ventilation and equable warm temperatures are depressing, debilitating, and retard recovery. Even dampness does no harm where there is a good current of air."

Further on he says: "Why have we been so slow to recognize that fresh air is the best tonic, the best antiseptic? It is cheaper, pleasanter, and undoubtedly more efficient than drugs." And he quotes from the report of Surgeon-General Billings, who says in his report of the medical and surgical history of our civil war, speaking of hospital construction: "The object to be kept in view is to furnish shelter without diminishing that supply of pure air and light which is necessary to health."

From this it can be safely inferred that the sufferers in the present war will have fully as good a chance of recovery in the open tent hospital of the field, or possibly a better one than if treated in one of the showy structures of which all great cities are so proud.

NEW AMBULANCE RAILWAY TRAINS.

On arrival from France and Belgium at the various ports and harbors on the south and east coasts of England, the British wounded soldiers and sailors are conveyed to hospital bases at various selected inland places in a number of specially constructed ambulance trains, several of which have been provided by each of the leading British railway companies. Four of these new railway ambulance trains have been constructed by the London and North Western Railway Company, three being for the War Office and one for Admiralty, of which some illustrations are given. The vehicles were taken from main line traffic and altered to suit required conditions, and the trains were completed in 30 hours. The center vehicles are for the accommodation of patients, those at either end being for the convenience of the staff, stores, etc. In the military trains the ward or hospital cars have a pharmacy car in the center. All the carriages were thoroughly well cleaned inside and outside, overhauled, revarnished, and the whole of the interior finished in white enamel, and special ventilators were fitted in the clerestory roofs. The ward cars were converted from open parcel vans, which were already provided with sliding doors on the sides and ends. These were refloored, covered with linoleum, coved at all angles, and hooks were fixed in the ceilings for suspending cots in two tiers on both sides, for the naval train, and folding berths, in two tiers hinged to the sides for the military trains. The pharmacy car in the center of each train is subdivided into treatment room, pharmacy, office, linen stores, etc., and fitted with all necessary requirements such as cupboards, shelves for drugs, medicines, bandages, and utensils. Dining cars are attached to each train, for providing meals, etc., for the staff and patients; and the trains are vestibuled throughout.

CHARACTER OF WOUNDS.

In considering the treatment of the wounded in war the nature of the wounds becomes a matter of importance. The modern rifle shoots a small bullet at a very great velocity, and although there may be some slight variation in the action of the bullets used by different nations, as there are differences in size, shape, and velocity, still at the present time all classes of modern army bullets are supposed to behave practically alike, and opportunities for studying their action and effect have occurred in our war in Cuba, in South Africa, and other places.

From these observations it appears that between the distances of 300 and 900 yards the wounds made are of a penetrative character, even in the case of bones, and unless foreign matters, such as bits of clothing, are carried into the wound, there is seldom any infection, and the wound heals rapidly without trouble. At shorter or longer distances the action of the bullet is erratic, splintering bones badly, and frequently turning over so that it strikes sideways, producing lacerated wounds. These effects are also liable to be produced at any range if the bullet strikes some object, and is deflected in its course. Another effect produced by these high velocity bullets is a disruption of the softer tissues of the body that often leads to the impression that an explosive bullet was used; but the exact cause of this action, and the conditions under which it takes place, is not understood.

That the wound made by the modern high velocity bullet, covered with its nickel jacket, is more or less aseptic, and that a large proportion of the wounds made by them are not of a serious nature, and give but little trouble, has been demonstrated by the records of the conflicts mentioned above. In this respect the work of the army surgeon of the present day has certainly been simplified, and the percentage of fatalities from bullet wounds in the present war will show a material decrease.

Disinfecting the Mouth with Ultra-Violet Rays

It is well known that the ultra-violet rays, those "dark rays" or radiant energy which lie just beyond the violet end of the solar spectrum, have the power of killing bacteria. They have been used successfully to sterilize water, and it is to them that the power of sunlight to kill germs is due. The bactericidal power of the sun is relatively small, however, because these rays, which have a very short wave-length, are largely absorbed by the atmosphere before they reach the earth.

To obtain an intensive effect of these rays, therefore, they are produced by an artificial source. The ultra-violet rays from the mercury lamp are very deadly to bacteria. Finsen, notably, has used them with great success to treat superficial skin diseases, especially lupus. They are not adapted, however, to the treatment of diseases when the bacteria have involved the internal parts of the body, since, owing to their short wave-length, they cannot penetrate the deeper tissues.

Recently, however, it occurred to a German physician, Dr. E. Friedberger, and his Japanese colleague, Dr. E. Shioji, that these rays might be employed, by means of suitable apparatus, to disinfect those cavities of the body which have an external opening, especially the mouth and nose. These are peculiarly important, because they are the port by which many dangerous germs enter the body. An account of their experiments is contributed by these investigators to *Die Umschau* (Frankfort). We read:

"We need name only the germs which cause inflammation of the lungs, tuberculosis, infantile paralysis, and, above all, diphtheria, among the very various germs which enter or have their chief location in the cavity of the mouth, of the nose, or on the tonsils. The possibility of killing the germs in these cavities, therefore, is highly important. The more so from the point of view of epidemics, since it is well known that some persons on recovering from a disease become 'bacillus-carriers,' while others, though not themselves ill, are known as 'go-betweens' (Zwischenträger), who carry germs from one person to another."

Since irradiation from outside is not very effective, owing to the law that the intensity of the rays and their germicidal power decrease in proportion as the square of the distance increases, Dr. Friedberger and Dr. Shioji endeavored to construct an apparatus which would enable them to place the source of the light within the mouth itself.

"We have applied a special device of quartz to the mercury lamp and began our experiments with guinea-pigs, placing this device directly within the mouth. The mouth of the guinea-pig, like every cavity of the body which has an external opening, is filled with countless numbers of bacteria. We proved that irradiation of the mouth for only a few minutes sensibly diminished the number of germs, and that after twenty minutes there was practically a total destruction of them. This may be illustrated by an example. The following results were obtained by alternating five-minute periods of irradiation and cessation:

NUMBER OF GERMS ON THE AGAR PLATE.

Before irradiation	144,000
After 10 minutes' irradiation	85
After 20 minutes' irradiation	5
After 30 minutes' irradiation	3

"Similar experiments were also made after enormous quantities of diphtheria and other germs had been introduced into the mouth of guinea-pigs. In these cases also the irradiation quickly destroyed the germs.

"The following results were obtained by similar experiments with the *bacillus prodigiosus*. Before the irradiation there were numberless colonies of *prodigiosus*.

	Colonies.
After 10 minutes' irradiation	318
After 20 minutes' irradiation	1
After 30 minutes' irradiation	0
After 24 hours' irradiation	0

"The next step is to investigate to what extent this method may be applied to all possible human diseases of the mouth cavity, especially diphtheria. A difficulty is found in the circumstance that even ten minutes' application of the ultra-violet light is sufficient to cause a burn."

Soil Erosion in South Africa

At a recent agricultural meeting in South Africa one of the principal topics of conversation was soil erosion, a subject which is of growing importance in the stock raising districts on account of the rapidity with which vast tracts of land are becoming practically sterile. It has been suggested that the soil erosion which is going on in South Africa is due to the natural and inevitable desiccation of the country, but the consensus of opinion at the meeting was that it was due to the destruction of the grass which naturally binds the surface soil and forms a retentive mass that absorbs moisture and prevents the rapid run-off of rainfall. The destruction of the grass was attributed to two causes: the indiscriminate burning, frequently just previous to the wet season, and the constant driving of cattle along the bottom of natural hollows. There are numbers of examples of the drying up of vleis, and in every case one can attribute this to the formation of a river which started first as a small sluit and gradually developed into a larger river.

Some Novel Slow-Speed Motors

A New Power System Utilizing Different Voltages

The new type of three-phase motor which is constructed by the Oerlikon Works is of interest from the fact that it runs at several speeds, and is designed for very slow speed work and heavy flywheel effect. Such motors are very useful, for instance, for direct drive of piston pumps, and can thus be employed in a great number of plants in which there is required a very slow speed with a good range of speed regulation. Fig. 1 shows the new type of motor, together with transformer and motor-starter. A number of these motors were installed in one of the large coal mines in Cornwall, where they serve for piston pumps on direct drive. The design is that of a short-circuit motor with the rotor in flywheel shape, so as to overcome irregularities in the running, and have the following conditions:

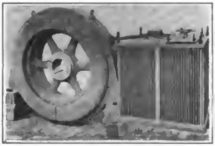


Fig. 1.—Oerlikon motor for various speeds, with its transformer and controller.

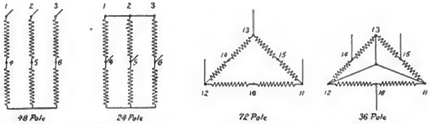


Fig. 3.—Diagram of the various connections in the Oerlikon variable speed electric motor.

Speeds.	First.	Second.	Third.	Fourth.
Power, horse power......	35	55	72.5	110
Number of poles........	72	48	36	24
Revolutions per minute...	38	60	82	118

The voltage is 2,700 to 3,000 volts, and frequency 25 cycles. Motor starting is done by starting transformers which are mounted together with pole-changers. According to the specifications, the motors were required to start upon 2,700 volts and have a starting torque equal to the normal. Conditions of temperature and dampness in the mine where the motors were to be installed are specially unfavorable, there being a mean temperature, 37 deg. Cent. and dampness 80 to 85 per cent, so that the coils had to be impregnated several times as protection against dampness.

In designing motors for this class of work, the first idea was to use the high-tension current directly in the motor itself, but further considerations showed that both motors and transformers would be cheaper to build, and would work with less trouble, if the transformers were not designed for mere starting but to take the whole of the power, the motors, on the other hand, to work upon low tension. In the present make-up, the stator of the motor has two sets of windings, one for 24 and 48 poles, and the other for 36 and 72 poles. Owing to the construction of the transformer and pole changer in one apparatus, this allowed the choice of the best voltage to use on the motor for each combination of poles, so that the windings can be made as bar windings on the stator. The increased cost due to the use of transformers for the whole power, instead of for starting purposes, was amply made up by the more simplified windings and also by the smaller size of the motor. The stator is seen in the rear in Fig. 2, and the winding is laid in 432 slots, the winding used for 24 or 48 poles being composed of forty eight sets of coils per phase. Connections are seen in the diagram, Fig. 3, six terminals being used. Nos. 4, 5, and 6 each come off from twenty four sets of coils. If the motor is to work on 48 poles, the current leads are joined by the starting switch to ends Nos. 1, 2, and 3, while ends 4, 5, and 6 are free. For 24-pole working, the current is now put on 4, 5, 6, and 1, 2, 3 are short-circuited.

The system of winding for 36 and 72 poles is composed of 72 coils, and is placed as near as possible to the air gap so as to lessen the dispersion which is greater than with the other pole set. Connections for these windings are shown in the diagram, and here six terminals are also used. Nos. 14, 15, 16 come out at each set of thirty-six coils. Where the motor works on 72 poles, the switch puts current on Nos. 11, 12, 13, while the others are free. For working at 36 poles, 11, 12, 13 are short-circuited, and current comes on 14, 15, 16. It will be seen that there is a total of twelve terminals on the motor.

Regarding the bar winding of the stator, both windings are laid with bars, and each system employs four bars in each slot, using a tube of compressed mica on each bar. Half-open slots are used in order to introduce the lathe-wound coils. Stator laminated iron is held, as usual, between end rings, but as the motor goes as low as 3.0 meters a second periphery speed there is no ventilation to be had by this means, so that no air holes are provided in the stator mass. Maximum periphery speed is about 10.8 meters a second. The section view of the motor, Fig. 5, makes the different parts clearly visible. The laminated rotor is of the usual design and has a squirrel-cage winding, using copper bars laid in 528 slots. The ends of bars are forced into a copper ring previously perforated to receive them, then brazed with silver on the most approved method, and this gives a strong and very reliable construction for the rotor, which avoids all accidents.

One of the original features of the Oerlikon method is the mounting of the transformer and starter box in very compact shape with the rotor, as will be observed, and by this design there are only very short connection wires to the motor. Other views show the transformer and the starter as contained in the oil box, the cover being made in two parts. One half covers the transformer, while the whole of the motor-starter is suspended from the second cover so that it can be readily lifted out. Connections between starter and transformer are made by binding posts mounted on the two covers, which are joined across by small copper strips.

The motor-starter, Fig. 4, is made up of three cast iron drums of controller type, which work together in the same movement by the use of gearing at the top, and the hand-wheel thus turns all three drums at once. One drum corresponds to each phase of current, thus avoiding crossings and connections. The iron drums are mounted on square shafts from which they are insulated, and carry screwed copper contact plates. Fixed contacts for each drum are carried on a wood strip, and the current break comes upon auxiliary contact pieces which are easy to replace, while the main pieces are undisturbed.

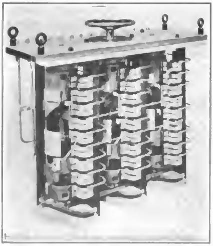


Fig. 4.—Interior view of controller and starter.

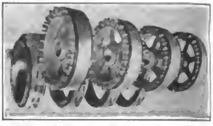


Fig. 2.—Stators and rotors of the new motor.

The weight of the present motor, including foundation plate, but without bearings or shaft which properly belong to the pump, is about eight tons; weight of transformer and starter outfit, 2.2 tons.

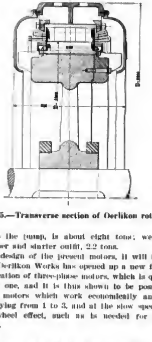


Fig. 5.—Transverse section of Oerlikon rotor.

In the design of the present motors, it will be seen that the Oerlikon Works has opened up a new field for the application of three-phase motors, which is quite an important one, and it is thus shown to be possible to construct motors which work economically and with speed varying from 1 to 3, and at the slow speed with good flywheel effect, such as is needed for mining pump use.

A New Way to Make Steel Joints

A new material called "amalgaline has been introduced in England for making joints between lead surfaces, and it is said to have been widely adopted by shipbuilders in Scotland and the north of England, as it is useful in flanging and the seaming of lead used in lining refrigerating chambers. The system is not confined to use on small pipes, but is used in an ordinary way on pipes varying in bore from 3 inches to 9 inches. Like lead burning, it is an autogenous process, but instead of using an intense local heat the fusion is effected by the action of the amalgaline on the surfaces it is in contact with, forming an amalgamation between the lead of the flange and the lead pipe. The material used is in the form of a metallic ribbon of 0.002 inch in thickness, practically a pure metal, which, when placed between the surfaces of lead and subjected to heat, fuses at a temperature of 100 degrees lower than the actual fusing point of lead, and in fusing it causes the lead surfaces to run together at a lower melting point than that of the body of the lead. This running together has an autogenous effect, and by intermolecular absorption the minute particles of amalgaline are dissipated into the body of the lead, which, by reason of the absorption, becomes stronger at the junction than elsewhere.

New Experiments with Liquid Air*

AT the temperatures of liquid air (—182 to —194 deg. Cent. according to the proportion of oxygen) organic tissues become more brittle than glass. "Burns" caused by liquid air do not heal in months, and a finger that has been immersed in the liquid for a sufficient time can be broken as easily as a window pane. Nevertheless it has been proved by recent experiments that highly organized animals live in liquid air.

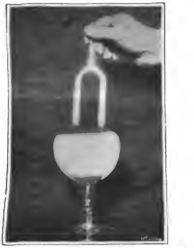


Fig. 2.—A glass fork cooled by liquid air and exposed to the atmosphere becomes covered with ice, smooth on the right fork, but brush-like on the left, which has been electrified by rubbing.

A goldfish immersed in liquid air was instantly frozen, but it revived and swam vigorously a few seconds after it had been replaced in water (Fig. 1). It showed the effect of its experience in the intense red color of its gills, but it probably suffered little pain, for liquid air is used as a local anæsthetic in surgery.

Fig. 1.—Goldfish frozen stiff by immersion in liquid air, quickly resumes its activity when replaced in water.

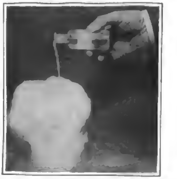


Fig. 3.—Alcohol poured into liquid air overflows the vessel as an avalanche of snow.

The behavior of electrified glass rods at the temperature of liquid air is very interesting.

Fig. 2 shows a glass fork with its right prong coated smoothly with ice, while the left prong is covered with little icicles, arranged radially. The left prong had been electrified by rubbing it with a piece of leather, and the brush-like form of the coating of ice is due to repulsion of the congealing particles of aqueous vapor condensed from the atmosphere.

Fig. 4.—A leaden bell rings clearly after immersion in liquid air.

Fig. 3 illustrates the freezing of alcohol by means of liquid air. Wine, beer, and distilled liquors are instantly frozen solid when they are poured into liquid air. But the freezing of alcohol, which occurs at —110 deg. Cent., liberates so much heat that the liquid air is thrown into violent ebullition, and the congealing alcohol overflows the vessel as a little avalanche of snow.

Almost all liquids are solidified and almost all solids are hardened and stiffened by immersion in liquid air. India rubber tubes become as brittle as glass. A leaden bell, which produces no musical tone at ordinary temperatures, becomes as hard as steel and rings as clearly as a bell made of bell metal (Fig. 4).

* Translated from Umschau.

Approximate Measurement of Textile Fibers

By N. A. Cobb

THIS note is hardly the place for the demonstration of the following theorem. However, it is readily capable of demonstration, and the reader with a mathematical turn of mind will at once perceive the line of proof.

Theorem.—If an infinite series, consisting of straight parallel linear elements of every possible length, each element arranged perpendicularly to and symmetrically to a given straight line, be bisected along that line and the two half-series thus produced be placed with the former outer edges adjacent; then, if the elements of one of the half-series be systematically rearranged, its longest element matched to the shortest of the other half-series and its next longest to the next shortest of the other half-series, and so on, a new parallel-sided series will be produced, each of whose elements has a length equal to the mean length of the elements of the original series.

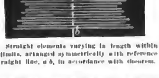


FIG. 1.—Straight elements varying in length within prescribed limits, arranged symmetrically with reference to a given straight line, a b, in accordance with theorem.

If the theorem be changed so that the elements are stated to vary in length within prescribed limits, then for this modified theorem the line of demonstration as well as the final result is the same.

If the number of elements is limited, say, for example, to a few thousand, the result becomes approximate; and if the elements, instead of having their middle points on the given straight line, are arranged so that their middle points fall at random on either side of the given straight line a distance less than half the length of the shortest element, then the reconstructed series will have a width approximately equal to the mean length of the original elements; for it will always be possible to pair the elements whose middle points fall to the right with those whose middle points fall to the left in such a way, the long with the short, as to secure the result stated in the theorem approximately, the degree of approximation depending on the number of the original elements and the uniformity of their increments in length when arranged in the order of their magnitude.

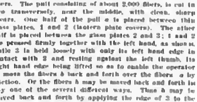


FIG. 3.—Application of the theorem to the measurement of textile fibers in mass; for instance, a "pull" of cotton fibers. The pull consisting of about 2,000 fibers, is cut in two transversely, near the middle, with clean, sharp shears. One half of the pull a is placed between thin glass plates, 1 and 2 (lantern plate covers). The other half is placed between the glass plates 2 and 3; 1 and 2 are pressed firmly together with the left hand, as shown, while 3 is held loosely with only its left hand edge in contact with 2 and resting against the left thumb, its right hand edge being lifted so as to enable the operator to move the fibers b back and forth over the fibers a by friction. Or the fibers b may be moved back and forth in any one of the several different ways. Thus b may be moved back and forth by applying the edge of 3 to the cut ends of the fibers. Care must be exercised not to disturb the parallelism of the fibers.

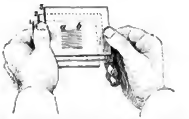


FIG. 4.—The halves of the "pull" shown in Fig. 3 matched ready for measurement. The halves are adjusted against a strong transmitted light. b is so adjusted over a that the fiber masses present the same shade from end to end. When so adjusted, the three glass plates are held in the left hand, while the measuring scale is applied with the right hand. This simple optical method is found to approximate the conditions of the theorems. The width of the series as arranged in Fig. 4 represents the mean length of the fibers minus the "fly-back." This latter, about one millimeter in twenty-five for well conditioned cotton fibers, has to be added. The results are accurate to the fraction of a millimeter. The method is definite, readily learned, and easily applied.

It has been ascertained by comparison with the results of my accurate method of measuring the length of fine crooked fibers, a description of which has already been published, that if a series of fibers be arranged in a manner similar to that described in the theorems, the mean length of the fibers can be measured approximately, if proper allowance be made for the "fly-back," or apparent shortening of the fibers, due to their elasticity. The method is more definite and more accurate than that in common use by cotton experts.

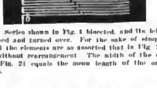


FIG. 2.—Series shown in Fig. 1 bisected, and its left half transposed and turned over. For the sake of simplicity, in Fig. 1 the elements are so assorted that in Fig. 2 they match without rearrangement. The width of the second series (Fig. 2) equals the mean length of the original elements.

Manufacturing Conditions in Germany

ALTHOUGH the great metal manufacturing establishments of Germany have lost their export trade, they are still being operated to their limit in turning out war and railway material on government orders, being obliged to work night and day. Many of these works have lost nearly one third of their men to the army, but several are endeavoring to supply the deficiency by taking on men from other industries that are suffering from depression.

The question of employing prisoners of war, especially in mines, has also been raised, as it is of paramount importance to maintain a continued supply of coal. The coal mines in the Ruhr district must now serve a much larger area than before, owing to the cessation of the imports of English coal. Many mines have lost about 40 per cent of their men by mobilization, and the supply of coal is diminished by about one half.

Design of Floats for Hydro-Aeroplanes—II*

Giving the Results of Tank Experiments with Various Models

By G. H. Millar, B.A.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2028, Page 320, November 14, 1914

Considering the form of the bow, it will be seen that type 2 is really an intermediate form between types 1 and 3. The curves of resistance show that type 3 is a good deal the better. With these flaring bows the "mud-guards" shown are essential. The first model made of type 2 was run without "mud-guards" and with no air-holes to the step. The result was that a filmy wave ran up the side of the model, no air could get to the step, and the resulting suction held the float down so firmly that it never rose at all. The "mud-guards" throw the water clear of the sides, and at the same time derive a large lift from it.

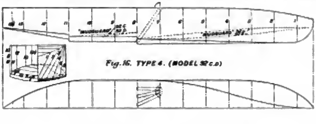


Fig. 16. TYPE 4. (MODEL 92c.d)

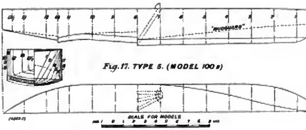


Fig. 17. TYPE 5. (MODEL 100b)

The type 3 float, although quite satisfactory from a resistance point of view, was found to induce an excessive positive trimming moment at about the "hump" speed, which would naturally tend to tilt the machine at this speed until the tails of the floats were in the water. This was confirmed by tests with an actual machine fitted with such floats. To obviate this trouble a series of experiments were made with models having two planing surfaces, of which that shown in Fig. 17 (type 5) proved the most successful. It will be noticed that the shape of the after termination has been altered from a pointed one to one with a vertical stern-post, and its chines rounded off to reduce eddy-making at the low speeds during which it is in the water. The flat bottom of type 3 has now been replaced by a cambered one of circular section. This is much stronger and less liable to slam, and the loss of efficiency is negligible. It is, however, important, if using a cambered bottom, to make the camber constant or decreasing from forward to aft. A surface in which it increases going aft will be extremely inefficient.

The shape of the bow has been altered slightly to increase the stability at small angles, and the "mud-guards" have been straightened out and lifted at their fore ends for the same reason. Although the flaring bow makes for stability in the same way as the overhang of type 1 float, it must be remembered that it also will throw up the water as soon as the fore ends of the "mud-guards" are submerged. As the resistance term tends to reduce the righting moment, the upper water-lines should be kept reasonably fine.

The results obtained from the six models illustrated are shown in Figs. 18 to 27. The model denoted by 92e consists of the forebody of 92c with the middle body and tail of 100b while model 100 differs from 100b in having the hollow of the after plane filled in.

The first point of interest is the comparison of the curves of "linear rise" with those of resistance. The "linear rise" of a float denotes the vertical height of the float above the statical position under full load, its angle being maintained constant. The study of a large number of such curves of rise shows that normally there is a speed at which the rate of rise becomes rapid, and this speed is always just below the "hump" speed on the resistance curve. If there is a good deal of steady rise before this speed is reached, the corresponding part of the resistance curve will be lowered, and the "hump" will occur at a rather later speed. This is particularly noticeable in the case of model 92e, where the second planing surface is 7 deg. steeper than the first, and has therefore a greater efficiency than if parallel to it. Model 98 (type 1) has quite a different curve—a long, steady rise—and it will be noticed that the resistance curve has two humps, the space between them covering about the middle third of the rise. It was found that in every case where a float rose evenly and gradually the hump on the resistance curve was flat and spread out, or there were two humps with a hollow in between. The peaky curves usually show traces of a second hump some way down the slope. In the case of model 98 it is practically certain that the second hump is due to the suction of the waves against the sides near the stern (see Fig. 10), and it will be noticed that there is an exactly corresponding increase of the positive moment owing to this cause. When these side waves leave the stern the resistance and moment curves both come down.

FIGS. 18, 19, 20 IN MODEL UNITS (ONE FLOAT)

Fig. 18.

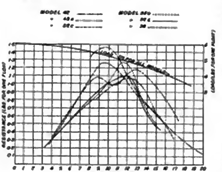


Fig. 19.

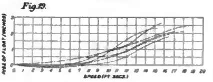
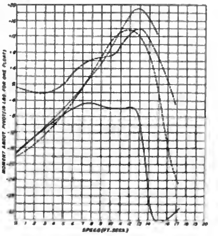


Fig. 20.



Clinging side waves of this type do actually occur against the sides of the tail in the case of the other models, but only at a much lower speed. They pass off astern at a speed of about 9 foot-seconds for the model. It may be said generally that the drop after the hump on the resistance curve shows that there is no longer any appreciable resistance to the float rising in the water. Provided that the bottom is of a suitable hydroplane type, it will always give a good lift even at speeds well below the "hump," and such resistance is due either to the suction of waves against the sides of the float, or to suction on the bottom caused by an unsuitable shape or an insufficient supply of air to the step or steps. Experiments with stepped models, with and without air-holes, always show that the model without air-holes rises later, and, consequently, has a later and bigger "hump" on the resistance curve. In the double-stepped models air-holes were only fitted to the forward step, it being impracticable to fit them to the second step owing to the after weight pocket being over it. It is highly probable that an improvement would result from fitting them, and that the later "hump" on the curve of 92e (as compared with 92c) is due to greater suction aft of the second step, its greater angle deflecting the water more downward, and so leaving a bigger vacuum to be filled.

Any form of float in which the waves tend to cling to the sides needs "mud-guards" of some kind to throw the water clear; and, to render them really effective, they should be of a fair breadth. With a float, whose sides are vertical, a sharp chine at the junction of the sides and bottom without any projecting plane, will be fairly effective. The experiments with double-step floats showed the desirability of fitting "mud-guards" to the second step as well as to the first. The angle of the "mud-guards" should not be too great, or they will have a high resistance. On the other hand, their forward ends must be well up to give safety at small angles, and the almost straight ones of model 100b seem to be the most suitable.

In racing hydroplane boats the "mud-guards" are always made convex downwards, and they were so fitted in 92d, which only differed in this respect from 92e. They then had a much smaller effective angle, and gave a smaller lift at all speeds below the "hump," but also had a smaller resistance. The float rose very little till the "hump" speed was reached. It will be seen that in spite of this the whole resistance is greatly reduced at moderate speeds, but the "hump" is a good deal later and of a considerable height, owing to the waves tending to cling to the sides aft of the second step. On the whole, therefore, little is gained from this shape of "mud-guard," while the stability at small angles is decreased. But in the case of multiple-step floats, where the "mud-guards" are of a restricted length, it may be useful to curve them in this way, so as to keep their forward ends up with a smaller effective angle.

As was mentioned above, floats with two planing surfaces offer advantages in respect of the trimming moments involved. The line joining the steps should be at about 5½ deg. to the mean forward planing surface, and to render the second surface effective it should have a greater angle than the first. This is shown very clearly by the remarkable difference in the moment diagrams for models 92c and 92e. If, however, the distance between the steps is increased, the angle of the second step should be correspondingly decreased. This is obvious from a consideration of Fig. 8. The second step also decreases the resistance considerably. All experiments showed that where a double-step float at a planing speed could be made to run either on the forward planes alone, the back plane alone, or both planes, by slightly altering its angle, the smallest resistance was obtained when running on both planes. This is to be expected, as we have two planes immersed of a larger aspect ratio in place of one plane of a smaller aspect ratio.

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* Paper read at the joint meeting of the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-on-Tyne. Reproduced from Engineering.

It is not, of course, in any way a necessity to fit the overhanging tail shown on the models. If desired, the second step may be at the after end of the float, and the upper surface sloped down to it, so that the float terminates in a horizontal edge.

There seems no reason to increase the number of planing surfaces beyond two. With a greater number it will be difficult to divide the work equally between them, while the length of entrance will be decreased, and the "mud-guards" if any, will need to be steeper. Each additional step means more eddy-making, and therefore greater resistance at low speeds and greater constructional difficulties.

The importance of the horizontal position of the centre of gravity of the whole machine has been referred to above. The question of longitudinal trim may be attacked in three ways:—

1. The designer may attempt to design his floats so that at all speeds they shall run at any reasonable angle without introducing large trimming moments, either positive or negative. It is doubtful if this is at all feasible.

2. He may attempt to design a float which shall run steadily at nearly the same angle at all speeds, and shall resist any attempt to make its angle larger or smaller.

3. He may, by the judicious use of the tail float, produce a machine which will start off at a large angle and gradually come down to a small angle at high speeds, with or without the use of the elevator.

In the author's opinion, Condition 2 is the most desirable one to aim at. It is obvious that the machine will get off much more quickly if it is running throughout at its most effective angle.

A float of type 1 has a tendency to run at a large angle at moderate speeds and a small one at high speeds; and, although at a high speed the angle can be readily increased by the use of the elevator, there will be a sudden change of moment when the machine leaves the water, which may cause the tail of the machine to come down and hit the water.

Condition 2 seems to be most easily satisfied by a double-plane float approximating to type 5. Here the designer has a number of variables to deal with. He can shift the position of the C.B. at rest by shortening or lengthening the tail of the float, and can alter the position of either or both steps. It will be seen that for float 92c the maximum positive moment occurs at a low speed—about 6½ ft.-seconds for the model, equivalent to 15 ft.-seconds for the full-size machine. Hence, the machine can start off at a large angle with a considerable load on the tail-float, and can, therefore, manœuver comfortably on the water at very slow speeds, while taking up its most efficient angle at a moderate speed. It will be noticed that the moment diagrams show a large negative moment at high speeds. But at these speeds a reduction of 1 deg. to 2 deg. in the running angle will change this to a large positive moment, so that the machine will run quite steadily at an intermediate angle. The natural running angle can be varied by varying the relative depths of the points of the two steps. The positive moment at any speed can be increased to any desired extent by increasing g—i. e., by placing the floats farther forward.

It must be remembered that the experimental results only hold for smooth water. The effect of rough water will be to increase the resistance considerably, and hence to reduce the positive moments.

A point that must receive careful consideration is the possibility of the machine coming down at too high a speed and too small an angle through the pilot misjudging his distance from the water. Unless the floats are stable at small angles this is very likely to cause the machine to turn a somersault. The same requirement holds for running on rough water if the floats are to ride over the waves, and not plough through them.[1]

In conclusion[4], the author wishes to acknowledge his great indebtedness to Mr. G. S. Baker, at whose suggestion this paper was written, and in conjunction with whom the whole of the exprimental work was done, and to Mr. J. L. Kent, who assisted in this work. Also to the Advisory Committee for Aeronautics for their kind permission to make use of the experimental work done for them, and to reproduce a number of diagrams from the Official Reports.

The complete experimental results will be found in the following reports by Mr. G. S. Baker and the author, which are already published or in the Press:—Report No. 70, November, 1912; Report No. 98, November, 1913; Report No. 99, March, 1914.

APPENDIX.

Methods Adopted for Testing Hydro-Aeroplane Floats in the William Froude National Tank.

1. *Apparatus.*—The apparatus used for testing the floats is shown in Fig. 28. The floats are made with a flat upper surface which is parallel to the forward mean planing surface, and are screwed on to an aluminium carrier, at the forward end of which is a graduated arc *L*. The carrier is attached by ball-bearings *B* on a transverse horizontal axis to a vertical frame or gate *A* and a horizontal gate *C*. The forward end of the gate *C* is attached by other ball-bearings to the vertical gate *F*, and by a light-balanced steel rod to the dynamometer *D*. The forward frame *F* is supported on knife edges on fixed bearings and has balance weights *W*, *W*. The after frame *A* is also supported on knife edges, but the seatings are not fixed, but are suspended in vertical slides by light wires which pass over ball-bearing pulleys *P*, *P*, and carry weights on their other ends. Pointers are attached to the knife-edge seatings, and their height can be read off on vertical scales *S*, *S*. The frame *A* has balance-weights at the top, which are adjustable in amount, and two sliding weights on the upper arms, and a horizontally sliding weight (not shown on diagram) to balance the frame. *G* is a three-hinged frame to prevent lateral movement of the float. A stop can be clamped at any point on the arc *L*, which engages with adjustable jaws attached to the frame *C*. These jaws are opened just enough to allow the float to rock through a small angle (about ¼ deg. each side of the mean).

The method of running is as follows: The weights of all parts of the apparatus are known, and the forward frame is first balanced about *K*, a weight equal to that of the towing-rod and the proper share of the weight of *C* being suspended from *B*. The after frame is then balanced with everything in place, and the float just clear of the water and balanced about the axis *B*, so that there is no pressure on the stop. In any given run the correct load "*P*" is applied to the float by attaching suitable weights to the suspending wires, and the resistance (*R*) is measured by the dynamometer *D*. During the run, and before taking the resistance record, the float is accurately balanced about the pivot point *B* by means of movable weights on it, and a sliding weight on the float-carrier, so as to get the stop on the arc just floating between the jaws. From the position of the weights in conjunction with their position when the model is bal-

Fig. 21–27 IN MACHINE UNITS (TWO FLOATS.)

Fig. 21. 92c AT 6°

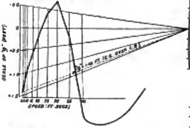


Fig. 22. 92c AT 20 FT. SECS.

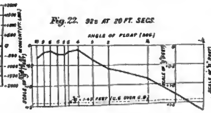


Fig. 23. 92c AT 30 FT SECS.

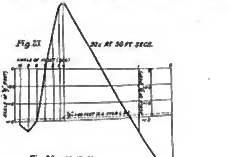
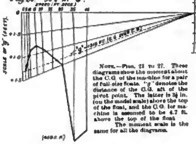


Fig. 24. 92c AT 6°.



NOTE.—FIGS. 21 TO 27. These diagrams show the moment about the C.G. of the machine for a pair of full-size floats. "g" denotes the distance of the C.G. aft of the pivot point. The latter is 3¼ in. (on the model scale) above the top of the float, and the C.G. for machine is assumed to be 4.7 ft. above the top of the float.

The moment scale is the same for all the diagrams.

Fig. 25. 92c AT 20 FT. SECS.

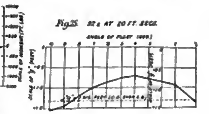


Fig. 26. 98 AT 6°

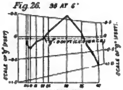
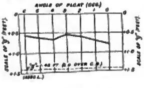


Fig. 27. 100 AT 20 FT. SECS.



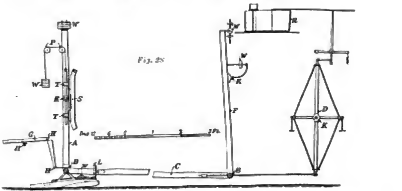


Fig. 28

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[4] Since writing this paper the author has come across a paper giving the results of some tests with models of flying-boat hulls made in the tank at Washington ("Hydromechanic Experiments with Flying-Boat Hulls," by H. C. Richardson, Naval Constructor, United States Navy—Smithsonian Misc. Collections, vol. 62, No. 2, April 20th, 1914). The results obtained seem to be in general agreement with those here described, but the information given is rather scanty, and the greater part of the paper is devoted to submerged experiments to determine the air resistance. (At the National Physical Laboratory this is determined more directly by means of the wind channel.) No attempt was made to measure the trimming moments when running on the surface.

anced in air at the same angle we deduce the moment (M) of the water forces about the pivot.

Let S be the dynamometer record (in pounds).

W_1 the weights of frame F acting at a height g_1 above K.

W_2 the weight of frame A acting at a height g_2 above K.

a_1 the radius of K B for forward frame F.

a_2 the radius K B for after frame A.

X the load on the wires carrying after knife-edges.

w_1, w_2 the components of the weight of C at the forward and after bearings.

θ_1, θ_2 the inclinations of frames F and A to the vertical.

ϕ the inclinations of frame C to the horizontal.

W the weight of float, carrier, and sliding weights and (f, g) the co-ordinates of their center of gravity relative to the pivot.

P, R the vertical and horizontal components of reaction of water on floats, and (p, r) the co-ordinates of the center of pressure relative to the pivot.

Then it can be shown that—

$$S = \left(w_1 - W_1\frac{g_1}{a_1}\right)\theta_1 + \frac{1+\theta_1\tan\phi}{1+\theta_2\tan\phi}\left[R + \left(-P + W + w_2 - W_2\frac{g_2}{a_2}\right)\theta_2\right] \qquad (1)$$

and

$$P = (W + W_2 + w_2 - X) + \frac{\tan\phi}{1+\theta_1\tan\phi}\left\{\left(w_1 - W_1\frac{g_1}{a_1}\right)\theta_1 - S\right\} \qquad (2)$$

$$Pp - Rr - Wf = 0 \qquad (3)$$

By our method of balancing we make—

$$w_1 - W_1\frac{g_1}{a_1} = 0$$

and

$$W + w_2 - W_2\frac{g_2}{a_2} = 0$$

Also $\theta_1 = \theta_2$ approximately, and both θ_2 and ϕ are small.

Hence equations (1) and (2) reduce to

$$P = (W + W_2 + w_2 - X) - S\tan\phi.$$
$$R = S + P\theta_2.$$

The angle ϕ is obtained from the vertical height scale, and θ_2 from the position of the resistance record on the drum. The air resistance of the apparatus at different speeds is obtained by experiment and deducted.

2. *Reduction of Results.*—No correction is made for surface friction in reducing the results for model to full-size float. The models are on a comparatively large scale, while they are actually so small that the frictional co-efficient is rather doubtful. Moreover, the amount of wetted surface varies greatly with the speed, and the speeds are so high for the length of float that the skin friction resistance is a comparatively small part of the whole. The error involved in neglecting the correction is only of the order of 3 to 4 per cent., and is always on the safe side.

This being the case, if the ratio $\frac{\text{model}}{\text{full-size float}} = \frac{1}{\lambda}$, then if P R are forces in pounds for model at a speed of v foot-seconds, and M is moment in inch-pounds for model at the same speed, the corresponding forces and moments for the full-size floats at a speed of $v\lambda^{1/2}$ foot-seconds are

$P\lambda^3$ lb., $R\lambda^3$ lb., $\frac{M\lambda^4}{12}$ ft.-lb. For the instance given above $\lambda = 5.67$, $\lambda^{1/2} = 2.381$, $\lambda^3 = 182.28$, $\frac{\lambda^4}{12} = 86.13$.

Radio-activity and Atomic Numbers

Let Th_T, Ra_T, Ac_T be the periods of half-change of corresponding members of the thorium, radium, and actinium family respectively, M the atomic number, M(Pb) that of the lead-group, and c a constant ($=4.5$); then for all substances emitting α rays:

$$Th_T = \sqrt{Ra_T \cdot Ac_T}/c^{M-M(Pb)}$$

For analogous β-radiators $Ra_T \cdot Ac_T/Th^2_T$, though not unity for group B IV., is >1 for B III., and <1 for B V. (the only three groups in which comparable values are known).

The only exception here, as in all similar relations, is thorium-X (or actinium-X). For radiothorium, where a few months as well as two years are given for the period of half-change, the formula gives the first value. Of course, very accurate results cannot be expected from values like 2 minutes, 3 minutes, 0.002 second, etc., but the differences are nowhere greater than what from this lack of precision must be expected.

	Periods of Half-change	Calculated	Experimental.
Radiothorium	$\sqrt{365 \times 10^6 \times 19.5}/4.5^2$	$d = 65$ days	A few months
Thorium emanation	$\sqrt{3.86 \times 86400 \times 3.9}/4.5^2$	$e = 56.4$ seconds	53 seconds
Thorium A	$\sqrt{180 \times 0.002}/4.5^1$	$a = 0.134$ second	0.14 second
Thorium C_2	$\sqrt{15 \times 24 \times 0.0333}/4.5$	$b = 2.83$ hours	2.87 hours
Ionium	$4.5^2 \times 65^2/19.5$	$d = 10^5$ years	10^5 years
Radium emanation	$4.5^2 \times 53^2/3.9$	$e = 3.12$ days	3.86 days
Radium A	$4.5^2 \times 0.14^2/0.002$	$a = 3.31$ minutes	3 minutes
Radium C_2	$4.5 \times 2.87^2/0.0333$	$b = 46.4$ days	45 days
Radio-actinium	$4.5^2 \times 65^2/365 \times 10^6$	$d = 19.5$ days	19.5 days
Actinium emanation	$4.5^2 \times 53^2/3.84 \times 86400$	$e = 3.5$ seconds	3.9 seconds
Actinium A	$4.5^2 \times 0.14^2/180$	$a = 0.0022$ second	0.002 second
Actinium C_1	$4.5^2 \times 10^{-22}/10^{-4}$	$a = 2.10^{-11}$ seconds	?
Actinium C_2	$4.5 \times 2.87^2/45 \times 24$	$m = 2.03$ minutes	2 minutes

—*A. van den Broek, in Nature.*

Fuel Alcohols

By Aug. Zimmermann

The great difficulties of discussing ethylic alcohol as a fuel are enhanced by the confusing terms used by some of your contributors. They are applying the word alcohol and spirit to several substances, nor do they differentiate between a proof and a liquid gallon when speaking of ethylic alcohol, by which means much misleading construction is being built up. Let us, therefore, agree in those discussions upon terms.

1. Ethylic alcohol, synonym, pure spirit, is obtained by fermentation of saccharine substances. This is quoted in this country in the market at per proof gallon, but delivered and invoiced in the form of liquid gallons, adding about two-thirds of the cost of the proof gallon.

2. Methylic alcohol, synonym, wood spirit, is obtained by the refractory distillation of wood, and is quoted and sold per liquid gallon only.

When Nos. 1 and 2 are mixed in certain proportions required by the Industrial Spirit Act, we obtain

3. Methylated alcohol or methylated spirit, which is also sold at so much per liquid gallon.

Our main object is, as I understand, and as I have myself always advocated, to arrive at a supply of ethylic alcohol, preferably made in this country from substances that are always with us, but if, at 1¾d per gallon this is an impossibility under any condition.

To make this clear I point out that the quantities of ethylic alcohol obtained from—

1 ton of wood waste or sawdust is 30-35 proof galls.
1 ton of molasses 50 per cent. sugar is 90-100 proof galls.
1 ton of pure starch is 225 proof galls.

The relative cost of these products is:

Waste wood about 15s per ton.
Molasses about £3 10s per ton.
Pure starch about £7 10s to £8 per ton

In working wood you obtain valuable by-products sufficient to pay for the working, while the treatment of starch is the more expensive process.

A simple calculation will then show that, considering the manufacturing expense, the proof gallon of ethylic alcohol cannot be produced at less than 1s per proof gallon, or about 1s 9d or 1s 8d per liquid gallon, and the methylated spirit would not cost much less than 2s per liquid gallon.

These are the only practical figures which should come under consideration, and they are, moreover, the utmost limits making an industry possible.

Considering the raw materials, I would mention that wood waste we have always with us in this country, and sufficient in ordinary times to produce about 3,000,000 liquid gallons of ethylic alcohol per annum, while molasses and cereals we have to import, and we cannot depend upon them in case of war, when more especially all cereals will be required for food purposes.

In considering the value of alcohol in modern warfare I remind you that the Japanese could never have carried on their war with Russia if it had not been for the supply of Russian spirit which they largely accumulated before declaring war on that country, and which, during the progress of that war, they were constantly importing from Hamburg and Liverpool. This is only to show what an important role the supply of alcohol plays nowadays in the modern requirements of a country, both for fuel and defensive purposes.—*The Daily Telegraph*, London.

Light in Gas-Charged Rooms

It has been shown by experiment that high candle-power electric lamps are dangerous in rooms where the atmosphere is charged with inflammable gas, for if the bulb is broken an explosion is almost certain to occur. Tungsten lamps ignited the gas in 25 to 85 per cent of the tests. The 8 candle-power 220-volt carbon incandescent lamp, however, caused only one ignition in twenty tests, and this was a test made by breaking the tip from the bulb and allowing the gaseous mixture to enter in a small stream which did not break the filament. For additional safety, it is recommended that wiring for electric light where gas is present should be installed in iron pipe conduits. If switches are used where gas is liable to be present, the switch boxes should be made gas-tight. As an additional safeguard the incandescent bulbs may have heavy glass outer globes and metallic shields outside.

We wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

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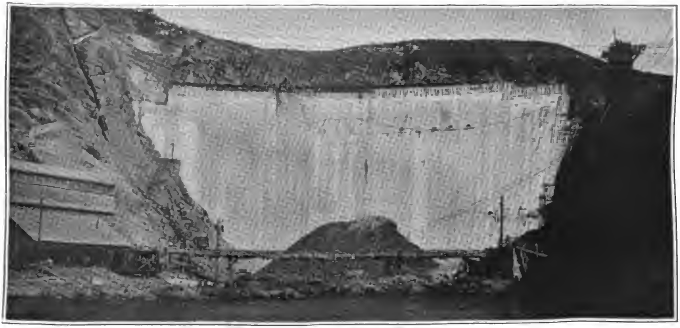
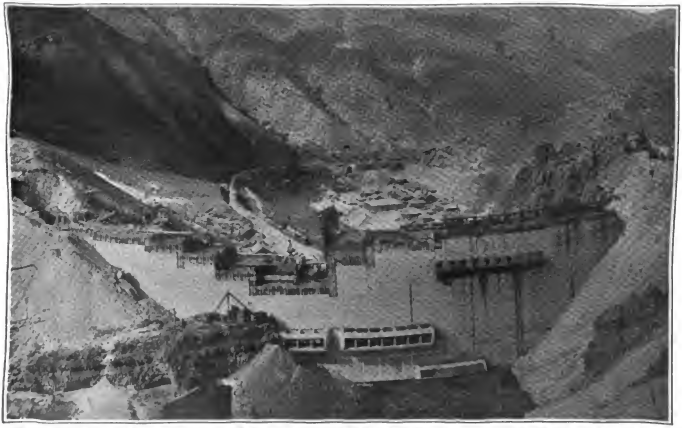


Part of the Arrow Rock Dam, seen from down-stream side. A sharp bend of the river bank conceals the right-hand end.



The Arrow Rock Irrigation Dam. Up-stream face, showing tunnel for the river during construction, also gates that regulate flow from the dam. This dam is 351 feet high and 1,060 feet long at the top.

THE ARROW ROCK DAM.—[See page 340.]

Electric Furnaces for Heating Steel—I[*]

Facts and Figures Relating to New and Valuable Methods

By Alcan Hirsch

The field of usefulness of the electric furnace for metallurgical purposes is so extensive that it is deemed advisable to limit the scope of this paper to a discussion of electric furnaces used for heating steel for the various kinds of heat treatment, forging and enameling. A broad view of the development of electric furnaces by the writer and his associates during the past year, together with details of design, construction and operation, as determined by them are presented herein. The essential data only are given as it is believed that extensive details are likely to lead to confusion.

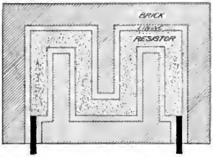


Fig. 1.—Serpentine resistor for moderately large furnaces.

Prior to 1913 attempts were made to put forth furnaces for metallurgical purposes, but except for the very small furnaces, these cannot be considered as having had commercial success. The facts which form the basis of this paper occurred under the writer's observation and are practically exclusively gathered from his experience of the past year.

By reason of industrial practice and certain other limitations, both fuel and electric furnaces can be divided into two classes:

I—Furnaces operating above 1,800 deg. Fahr. Forge furnaces are the main and most important division of this class.

II—Furnaces operating below 1,800 deg. Fahr. This class comprises furnaces for practically all heat treating as well as enameling. Although furnaces operating at the lower temperature will be considered first it must be borne in mind that the greater part of the principle and theory underlying the construction and operation of moderate and low temperature furnaces also applies to the higher temperature furnaces.

TRANSFERENCE OF HEAT FROM HEATING MEDIUM TO METAL.

The metal resting on the hearth of the furnace receives its heat in several different ways: (1) From the brickwork of the furnace in contact with the metal; (2) by conduction from the products of combustion; (3) by radiation from the hot walls, roof and incandescent particles in the burning gases. Generally speaking, in the fuel-fired furnaces, each of these paths delivers heat of the same order of magnitude, but usually the amount of heat passing by means of brick and metal in contact is less than that by any other path. If only a small portion of the heat passes into the metal by direct contact with the brick, the rate of heating in all except thin pieces is quite slow. More frequently than is generally supposed this path of heat transfer is the determining factor in the rate of heating. An excellent example of this kind was brought to the writer's attention where die blocks were being heated. In this instance the furnace was heated to a sufficiently high temperature so that the heat content of the brick work was sufficient to supply the necessary heat to raise the blocks to the desired temperature. Sometimes the fuel was allowed to run sparingly throughout the operation, while at other times it was shut off entirely after the block was placed in the furnace.

ATMOSPHERE IN FURNACES.

The atmosphere of fuel-fired furnaces is exceedingly uncertain. Slight variations in conditions have been found to make marked variations in results, and as the atmosphere is capable of a great many variations, it is, therefore, quite difficult to maintain it at a definite composition. With oxidizing conditions the formation of scale occurs, while in a reducing atmosphere local carburization results from the sooty flames. In the production of high-grade steel the condition of hearth atmosphere is, of course, exceedingly important.

The electric furnace provided in many respects just what the fuel furnace lacks; i. e., a means for the transference of heat in a very effective manner, and a furnace atmosphere which is not only of a very desirable composition, but which is absolutely dependable. This atmosphere is usually of a slightly reducing nature, caused by the presence of carbon monoxide, due to the combustion of the graphite or carbon resistor which liberates the electrical energy in the form of heat. In some furnaces having more than one door, or operated with doors open all the time, the atmosphere may be neutral. It is due to these neutral or reducing conditions that the formation of scale is greatly minimized. The writer has in mind an electric furnace which was operated with a loss of scale amounting to eighty or even ninety per cent less than was occasioned by the employment of an oil-fired furnace for the same work. For special work where an oxidizing atmosphere is required, as for instance in enameling, this is easily accomplished in the electric furnace by employing a muffle, the resistors being placed in any desired position on the outside of the muffle.

ELECTRIC FURNACES FOR TEMPERATURES BELOW 1,800 DEG. FAHR.

The industrial electric furnaces of this type which have obtained commercial success have employed a resistance wire or ribbon as the heating element. The limitations of these wire or ribbon-wound furnaces are quite marked, generally speaking, as regards both temperature and capacity. As will be shown subsequently, temperature and capacity of a furnace are closely interrelated. This interrelation of temperature and capacity, however, is not of so much consequence in the small furnaces where the combined wall and door losses are considerably in excess of the heat actually utilized in raising the metal to the desired temperature. The capacity of the metallic resistor is at most but a very few kilowatts. Furnaces with a larger capacity would be quite out of the question because of the cost of the resistance element due to the large amount of wire required and the expense of winding. The furnaces are, therefore, limited to productions of small size and also to rather moderate temperatures as danger of burning out due to overheating is quite imminent. For small furnaces, however, this type has proven quite satisfactory in a large quantity of work of an experimental nature.

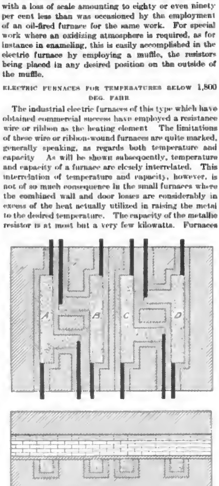


Fig. 3.—Furnace capable of regulation without a transformer—adapted for 10 square feet or over hearth area.

Furnaces employing non-metallic resistors comprise two types: (1) Those where the metal to be heated is in contact with the resistor; (2) those where the metal to be heated is out of contact with the resistor.

Furnaces of the first class have had but one commercial example, and that has had varying success. This is the bath furnace[1] which employs a conducting bath of salt, usually barium chloride and potassium chloride, which is used by the passage of the current through it. The steel to be heated is immersed in this bath of fused salts. This type of furnace appears to the writer to be too limited for extensive industrial application, and, therefore, will be given only this brief mention.

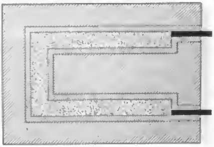


Fig. 2.—U-shaped resistor.

Furnaces of the second class, those employing non-metallic resistors, where the metal is heated out of contact with the resistor, hold forth much promise for future development, in the opinion of the writer. Recent experience with their operation has demonstrated their suitability to many kinds of work. In general, furnaces of this class appear to the casual observer, very similar to the fuel-fired furnaces, save for the fact that instead of equipment for burning fuel, electrical equipment will be noted. The electric current is brought to the furnace by suitable cables which are connected to electrodes projecting from the furnace. These electrodes run through the furnace wall and carry the current to the resistor which liberates, in the form of heat, the electrical energy put into the furnace. The resistor is a refractory conducting material, such as graphite, usually in granular form, and has a cross-section of 30 to 100 square inches according to the current desired. The resistors are usually placed beneath the hearth, the heat from them being communicated through the hearth to the metal.

For the design of a heat-treating furnace to operate at a hearth temperature of 1,800 deg. Fahr., or less, the following data have been found necessary for the preliminary calculation of the major points of design:

1—The hearth dimensions.

2—The production of metal per unit of time.

3—The maximum amount of metal on the hearth at any time.

4—The desired temperature.

5—Time for charging and discharging.

The first step in the design is the approximation of the location of the resistor, but this depends somewhat on the physical characteristics of the material employed for the resistor. Resistors placed in the furnace in granular or similar form have been much more extensively employed in the larger furnace than any other kind. Rods of graphite and also of other materials, metalloids as well as the characteristic non-metallic materials, have been tried for use as resistors. Although some of these will undoubtedly find commercial fields, as yet nothing has proven satisfactory in this direction. Attention, therefore, will be confined to granular or similar materials, of which granular graphite has served most satisfactorily.

For the usual type of electric furnace work of this class the location of the resistor is logically in the base of the hearth. For a small proportion of the furnaces, however, resistors can be placed elsewhere advisedly. These positions are along the side of the hearth and possibly even along the top. Furnaces requiring resistors in these latter locations are those taking piles of sheet metal or pots of materials, and the like. However, with one layer of pieces, which rests directly on the hearth, the location of the resistor had best be exclusively in the base. The reasons for this are: (1) heat has a tendency to ascend rather than to descend; (2) contact between hot brick and the metal to be heated facilitates heating; (3) the design is facilitated as will be subsequently developed. When the resistors are placed in the base of the furnace they are put in troughs of suitable refractory material and usually, but not always, covered partly or completely with brick or tile, which forms the hearth.

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[*] Author's abstract of report on research carried out under a Carnegie Fellowship granted by the Iron and Steel Institute of Great Britain. The complete report of this work was presented at the Annual Meeting of the Institute, May 7th, 1914. This abstract is reprinted from the *Journal of Industrial and Engineering Chemistry*.

[1] An article on this furnace by L. M. Cohn will be found in the *Electrotech. Zeit.*, August 2nd, 1906.

The shape of the resistors can be exceedingly varied. They may be straight, U-, S-, T-, or Y-shaped. They may be electrically connected in series or parallel, or some in series and others in parallel. They may be permanently electrically connected, or they may be capable of various electrical arrangements by switching.

PERMANENTLY ELECTRICALLY CONNECTED RESISTORS.

Furnaces with these resistors are constructed so that they must be operated in one manner, at all times from the point of view of electrical arrangement. In practically all furnaces of this class either a serpentine or U-shaped resistor may be employed, but two or more straight resistors connected either in series or in parallel may be used instead. Fig. 1 shows the serpentine resistor which has been employed in moderately large furnaces only, it being impossible to adapt this type to the smaller furnaces. The U-shaped resistor shown in Fig. 2 has been employed in furnaces of any size but has some limitations which will be considered later.

There are several ways to determine the electrical load for a given furnace, but they all resolve themselves into one method, which is the only one deemed sufficiently practical to be given consideration in this paper. Only furnaces of 200 kilowatts capacity or less will be considered and it may be said that furnaces for heat treating larger than this are exceedingly rare. The electrical load is the sum of three factors: (1) the electrical equivalent of the amount of heat necessary to raise the metal to the required temperature; (2) the electrical equivalent of the loss of heat through the walls; (3) the electrical equivalent of the loss of heat through the door, in consideration of the fact that this is alternately opened and closed. Since the power factors of furnaces of this size are from 97 to 99 per cent, they can be neglected in the calculation of the necessary wattage. From the data in Table I the watts necessary to operate any particular furnace may be approximated quite closely. The door loss shows the watts passing through the door opening if the door is open all the time. If the door is open only half the time, only half the amount given in the table should be taken, and so on in proportion. The wall upon which the wall loss figures are based is 12 inches thick, consisting of 9 inches of silica brick and 3 inches of kieselguhr. By actual practice this has been found to be a convenient standard. As an example of the method of caluulation, the electrical load for a particular furnace will be determined. Assume the following data for this illustrative case:

1—Outside dimensions—4 feet × 4 feet × 6 feet long.

2—Production—500 pounds of steel per hour.

3—Temperature—1,700 deg. Fahr.

4—Door—2 square feet, open 40 per cent of the time.

This furnace had a total outside area of 128 square feet. The table shows a wall loss of 0.060 watt per square foot, making a total loss of 7.68 kilowatts for the walls, top and base. The door loss would be 10.0 kilowatts if the door were open all the time, but it being open but 40 per cent of the time, the loss is 4.0 kilowatts. As 0.0881 kilowatt is required to raise 1 pound of steel to 1,700 deg. Fahr. from 60 deg. Fahr. in 1 hour, 500 pounds per hour would require 44.05 kilowatts.

TABLE I.

Temperature of operation.		Kilowatts to raise 1 lb. per hr. from 60° F.	Wall loss (a) in k. w. per sq. ft. outside surface.	Door loss (b) in k. w. per sq. ft.
° F.	° C.			
1000	538	0.0366	0.035	0.6
1100	594	0.0460	0.039	0.9
1200	649	0.0527	0.042	1.3
1300	704	0.0597	0.046	1.7
1400	760	0.0668	0.049	2.3
1500	815	0.0733	0.053	3.0
1550	843	0.0765	0.055	3.5
1600	870	0.0706	0.056	3.9
1650	898	0.0840	0.058	4.5
1700	926	0.0881	0.060	5.0
1750	954	0.0926	0.062	5.6
1800	982	0.0970	0.064	6.3
1850	1010	0.0994	0.065	7.1
2400	1316	0.122	0.085	20.0

(*a*) Based on wall 12 inches thick (9 inches of silica + 3 inches of kieselguhr).

(*b*) Door open all the time.

Thus it will be seen that this furnace will require 55.7 kilowatts for operation. No factor of safety need be applied to this figure if the conditions selected are at the maximum. On the contrary, if these are normal operating conditions a factor of safety should be applied according to the possibilities of greater demands being made on the furnace.

After calculating the number of kilowatts necessary for operation, the length of the resistor is approximated in order to determine the voltage. With granular graphite[3] experience has shown that the most satisfactory voltage is equivalent to 1½ volts per inch length of the resistor. From this voltage and the wattage as computed above, the number of amperes may be easily determined

The electrical resistance of a resistor in a furnace cannot be sufficiently closely predicted to warrant calculating the size of the resistor with a very great degree of certainty. Of necessity, therefore, the exact voltage which will be required for a furnace to take a certain number of kilowatts can be determined only approximately. A provision for obtaining various voltages is, therefore, necessary, and a transformer with several taps is ordinarily employed for this purpose. However, it is perfectly possible to provide a variable voltage generator for the same purpose. Since the precise production of steel for a given furnace cannot be very closely ascertained, and since, in most cases, different productions are desired at different times, it is absolutely necessary that provision be made for altering the kilowatt input at will of the operator.

The usual and satisfactory method of meeting these requirements appears to be the employment of a transformer with 10 to 15 taps. Usually 13 is a satisfactory number, having a range of voltages on the secondary from a minimum equivalent to one volt per inch length of the resistor to a minimum equivalent to two volts per inch length of the resistor. The various taps on the transformers used in most instances have given voltages which are in arithmetical progression, but it is the opinion of the writer that a progression of voltages in equal steps is best suited for the work. For the purpose of making provision for the uncertainty of the resistance of the resistor, the voltages would logically be chosen in arithmetical progression. For purposes of regulation, however, since the kilowatt input increases as the square of the voltage, it would appear, from this point of view, that the voltage steps should be graduated to best meet this condition. The two conditions must be met, and the most satisfactory arrangement is to make the steps in such progression that the difference of the kilowatt input on adjacent taps in the higher voltages will not be so very much larger than on the adjacent taps on the lower voltages. Accordingly, a satisfactory range of potentials on a transformer with 13 taps would have voltages equivalent to the following, per inch length of the resistor: 1.00, 1.10, 1.20, 1.29, 1.38, 1.47, 1.56, 1.64, 1.72, 1.80, 1.87, 1.94, 2.00.

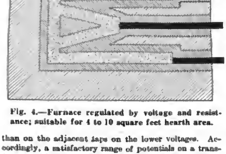

Fig. 4.—Furnace regulated by voltage and resistance; suitable for 4 to 10 square feet hearth area.

ELECTRICAL REGULATION WITHOUT TRANSFORMER.

A method[4] for obtaining this regulation and adjustment without the use of a transformer has been devised in the writer's laboratory very largely through the work of Mr. Richard S. Bicknell. In this type of furnace several resistors are employed, which are not permanently electrically connected, and which by means of suitable switches may be connected in various ways while the furnace is in operation. They may be arranged in series, in parallel or in any combinations necessary to effect the desired regulation. In other words, this is regulation by altering the resistance of the resistor as contrasted with the aforementioned method where regulation was affected by altering the voltage impressed upon the resistor. As will be shown subsequently this type of regulator is particularly adapted to furnaces having 10 square feet of hearth area or over. An example of a furnace capable of such regulation is shown in Fig. 3. With these four resistors in this particular furnace it is possible to obtain 110 inches in length of resistor, or equivalent of same, in the circuit at one time, and 220 inches in length of resistor at another. A large number of intermediate lengths of resistor between this maximum and minimum figure may also be placed in operation. This particular furnace is designed to operate on 220 volts and it will be readily seen that the maximum voltage obtainable per inch of resistor is two volts and the minimum is one volt. A quite surprisingly large number of intermediate lengths of resistor are obtained by employing the four T-shaped resistors, as shown. The length of the resistor is, of course, merely another way of stating the resistance of the furnace. These T-shaped resistors have each three unequal legs. Resistors *A* and *D* are similar and *B* and *C* are similar, but *A* and *B* have corresponding legs of different lengths. The resistance of the furnace resistors for a number of intermediate steps is made by connecting two legs in parallel in instances when a low resistance is desired. When a high resistance is wanted the resistors are run in series the current passing through the longest legs only. By properly proportioning the legs, it will be seen that the number of intermediate steps for purpose of regulation may be made as large as desired.

It is, of course, possible to combine these two methods of regulation, namely by voltage and resistance, having a few steps on the transformer and having one or a few resistors capable of being arranged either in series or parallel. A furnace so regulated is shown in plan in Fig. 4 and the method is quite suitable for small furnaces of from 4 to 10 square feet hearth area. The construction of the resistor as shown in vertical section would be quite similar to that in Fig. 3.

This discussion applies to both types of furnaces where the two methods of regulation are employed, i. e., either altering the voltage or the resistance. It has been found that a resistor placed beneath the hearth can be composed of two layers of materials to advantage, the upper of granular graphite and the lower of some material of lower electrical conductivity than graphite, such as charcoal. The lower layer takes a smaller part of the current than does the upper layer of graphite, thus placing the major part of the heat liberated quite near to the top of the resistor. This method seems to protect the part of the lining upon which the resistor rests. It protects it sufficiently well not only to warrant its use, but to make its use absolutely necessary in the case of furnaces operating close to or above 1,800 deg. Fahr. A resistor consisting of half charcoal moderately tamped by hand and half graphite gently tamped in is very satisfactory.

The width and depth of the resistor should be such that as much heat as possible is liberated in the desired direction. For resistors in the hearth this direction is, of course, upward. According to the theory, therefore, the logical shape of resistors of this sort would be as wide as possible and quite shallow. This section, however, is not at all feasible for several reasons. The resistor burns away more rapidly when it is wide and it is more difficult to spread the graphite on a wide resistor when it is replenished. Wide resistors require more lining and the expense of the lining is a relatively important item in the cost. When wide resistors are made to run at right angles the current has a tendency to flow across the interior corner in much higher intensity than at the exterior corner. Sometimes carbon or graphite blocks have been placed in the resistor at the corners for the purpose of reducing this local effect. This, however, is not a very good remedy, as the heat liberated in any event is not so great per unit area of the resistor in the corner as in other parts of the furnace. The cross-section of the resistors had, therefore, better be made about square, or wider than the depth by a small amount. If possible the resistors should not be narrower than their depth, but it is impossible to observe this requirement in all cases. Resistors less than 2½ inches wide should not be used. They should be not less than 6 inches deep and preferably about 7 inches, except for resistors over 10 inches wide which can be made 8 inches deep, though more than this is likely to cause excessive heating in the base of the furnace.

The designer frequently has the opportunity of employing one large resistor or two smaller ones to do the same work. Small resistors less than 3 inches wide should be avoided because slight variations in shape have a more marked effect on their resistance than in the case of the large resistors. It is much better as a rule to employ a short resistor 4 or 5 inches wide than a correspondingly longer one 2½ or 3 inches wide. On the other hand, large resistors are also to be avoided. Since the thermal conductivity of graphite is rather low it is evident that large resistors are much more likely to become excessively heated in their centers than small ones. Resistors 6 to 9 inches wide are to be used wherever possible, and for resistors of this type 12 inches wide and 8 inches deep are about the maximum dimensions for furnaces used for heating steel. This is quite too large, however, for any heat-treating work, but it is mentioned merely to give an approximation of the maximum limitation of this type of furnace. A 12 by 8 inch resistor would carry 1,000 amperes and a number of them could be arranged in a furnace so as to liberate 16 kilowatts per square foot of hearth. This is equivalent to a production of about 110 pounds of steel heated to 1,700 deg. Fahr. per hour per square foot of hearth under the usual conditions. This production is not only more than is usually desired, but is far too much for good work. Experience has shown that a maximum production of about 50 pounds per hour per square foot of hearth at 1,700 deg. Fahr. is all that can be expected in electric heat-treating furnaces.

(*To be concluded.*)

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[3] Artificial graphite averaging ⅛-inch mesh, but containing no fine powder.

[4] Patented.

The Arrow Rock Dam

By Chas. J. Lisle

ANOTHER "highest dam in the world" is being built by the United States Reclamation Service, and surpasses its record-breaking construction of the Shoshone dam in Wyoming and the Roosevelt dam in Arizona.

This new project, the Boise-Payette project in Idaho, is the outcome of a long effort on the part of the Idaho legislators to get the Reclamation Service to take up the storage problem for the waters of the Boise river. The government has been at work for some years on the reclamation of Idaho lands that will be served by this new dam, and has furnished water through the great Deer Flat reservoir, in which is stored some of the Boise river flood water. But the water supply has not been adequate, and not nearly all the land that must be watered from this project, if at all, has a water supply, except as the reclamation service supplies it.

The Boise river comes from the central Idaho mountains, through a narrow, precipitous gorge, which at various points furnishes excellent sites for storage dams. It was determined to build the storage dam at Arrow Rock, a point on the river about 32 miles from Boise. Work was begun two years ago, after an exhaustive preliminary survey.

The dam is to be 351 feet in height, with arch upstream, and is built of concrete, reinforced. The foundations go 80 feet below the river level. It is 100 feet wide at the base, has a bottom length of about 400 feet, and will be 1,000 feet in total length on top. It will contain 530,000 cubic yards of concrete. It will store water to a depth of 330 feet, and the back-water will extend for 20 miles up stream, making a beautiful mountain lake. It will store 230,000 acre feet of water.

The water is to be taken out through a series of five hydraulically controlled gates, 40 feet above the bottom of the structure. When the dam is full the water will come out at a head of 300 feet, and the gates must be of the heaviest character, and 1,000 tons of steel was used for the gates and accessories. They open into steel penstocks that carry the water through the body of the dam. As the needs of the irrigation season are so fluctuating, a wide range of control is provided. The dam could be practically emptied within a few weeks, if necessary.

Prior to the beginning of the actual work on the dam, the river was diverted from its natural bed, and carried through two 12-foot tunnels 1,000 feet long, cut through the rocky point which forms the west foundation of the dam. These tunnels are large enough to carry more than the highest known discharge of the river at flood time; and will be used for nearly a year longer, as it will take that long to complete the dam. The spillway is cut through solid rock some hundreds of feet from the end of the dam, so that there can be no cutting away of the structure by the action of the water.

A force of from 200 to 1,000 men have been at work steadily ever since the work was begun; and about 800 are now on the job. An interesting feature of the work has been the use of electricity from the government dam farther down the river, to furnish light and power for the work. The earlier dam was put in to divert the water to the government canals for the first part of the reclamation project; and later a power plant was put in, which now furnishes part of the power for the city of Boise, as well as for the building later of the greater dam. The only governmentally owned railroad in the Western hemisphere connects the Arrow Rock works with the outside world. It is 21 miles in length.

Coffee-Growing in Paraguay

THAT coffee can be cultivated in Paraguay is now being demonstrated by the success of a few small plantations in the Department of Altos, a short distance northeast of Asuncion, in the chain of hills extending from Brazilian territory as far west as the Paraguay River. For many years coffee has been produced in small quantities by Paraguayan householders for their own use. Until, however, the success referred to above, only failure has resulted from the efforts of those who have attempted to cultivate the tree for commercial purposes, largely because they neglected to study local conditions and adapt cultural methods thereto. Success has now been attained in the same localities where earlier efforts met with failure. According to Prof. Charles Fiebrig, a botanist of recognized authority and director of the Agricultural College of Paraguay, there are sufficient trees under cultivation in the Department of Altos to yield at present an annual crop of more than 330,000 pounds of coffee. The product is all marketed in Asuncion, where it is sold as Brazilian coffee. The producers of this coffee are Paraguayans, and it is noteworthy that this is the first result of anything like intensive cultivation, requiring a number of years to bring their work to fruition, by the people of this race. Prof. Fiebrig states that the region where the coffee trees are grown seems to meet all the requirements of the plant. The depth of soil, the rare occurrence of frost, which is never sufficient to endanger the plant, the general elevation of the land, and the abundance of trees giving the kind of shade necessary, all contribute to assure success if practical methods and the proper degree of care are employed. It is estimated that 500,000 trees will soon be in bearing in the Department of Altos. As much as 11 pounds have been gathered from a single tree, but this is exceptional. Ten thousand trees is the largest number on any one plantation, the average being 1,500 to 2,000.—*Journal of the Royal Society of Arts.*

Handling Rails Cheaply

ON some railroads rails are being loaded and unloaded mechanically instead of by hand. The machines used are operated by air pressure and usually handle a rail a minute, although in one case it is reported that three rails are being handled in that period. Modern locomotives have sufficient air capacity to provide power for the continuous brakes and the lifting machinery also; but where older engines are used a temporary steam pipe was coupled from the engine to a special pump for handling the rails. Where rails are so dealt with large gangs of men may be dispensed with. One company has been using electromagnets for handling rails and scrap, and it is said that these will lift twelve rails at a time or several tons of spikes. The magnets are operated from the jib of a crane, usually of the locomotive type.

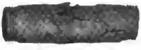
View of the great Arrow Rock Dam, showing spillway cut in solid rock around the end of the dam.

Calorizing*

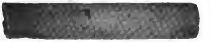
A Protective Treatment for Metal

By H. B. C. Allison and L. A. Hawkins, Research Laboratory, General Electric Company

SINCE the close of the bronze age iron has been used for ovens, utensils and tools of every kind for all temperatures up to dull red; but for higher temperatures there has been, even up to the present day, no cheap metal available. Platinum, because of its cost, has been quite limited in application, and the cheaper metals, such as copper, and most of the alloys, such as brasses and bronzes, will not withstand heating in the air to red heat. Nickel and cobalt are the most stable of those metals which may be worked or cast and are fairly cheap and will withstand moderately high temperatures. Some of the alloys containing nickel are also quite permanent in the air at red heat.



(a) Uncalorized iron pipe.



(b) Calorized iron pipe.

Fig. 1.—A piece of plain iron pipe and a piece cut from the same tube but calorized, after being subjected to the same degree of temperature for the same length of time.

Mr. T. Van Aller has discovered a process of heating metals in revolving drums with mixtures containing, among other things, finely divided aluminium, by which a surface alloy containing aluminium is produced. In the case of copper, this alloy is of the nature of an aluminium bronze, but richer in aluminium than the ordinary alloy of that name and more resistant to heat, so that copper thus treated is protected, up to the melting point of the alloy, from the scaling which occurs when untreated copper is heated above 300 deg. Cent. The same general result was obtained in the case of iron and steel. Some use was made of this process, which has been called "calorizing," for treating copper soldering irons and iron resistance wires for heating devices.

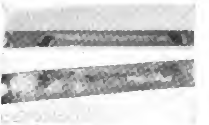


Fig. 3.—A section of calorized iron pipe (lower) and a section of uncalorized iron pipe (upper) after being treated to operating temperature for 400 hours.

Modifications of the process, extending it to further applications, were made by Mr. E. G. Gilson of the Schenectady Research Laboratory. Pieces which, because of their shape or size, are not adapted for tumbling, may be calorized by packing them in, or painting them with, a suitable mixture, and heating them. Thus, the size of the heater is the only limitation on the size of the piece that may be calorized. Wire or ribbon may be treated by a continuous process, by passing it through a heated pipe containing the proper calorizing mixture.

There appear to be many places where it is desirable to use iron vessels or apparatus at temperatures above red heat, and at such temperatures ordinary iron rapidly oxidizes and scales away. After iron is calorized the effect of heating is slight. Instead of burning and the scale falling off, as in the case of untreated iron, practically no effect can be detected after a considerable time—certainly none which injures the surface. This is well illustrated by the two pieces of iron pipe shown in Fig. 1, both from the same kind of pipe, but one of which (B) was calorized. The two were heated side by side, with an ordinary laboratory blast lamp to a temperature of about 900 deg. Cent. for a period of four hours, then cooled and the heat once more applied for another period of four hours. At the end of that time the untreated pipe (a) was badly burned, the point where the flame was directly applied having been reduced to one half the original thickness, while the whole surface was blistered. The contrast between this piece and that which was calorized (b) is very marked, for even upon close examination the calorized pipe appears to be unchanged.

In connection with the piece of calorized pipe used in this experiment, it should be stated that it had previously been used in other work, where it had been alternately heated to 1,000 deg. Cent. and cooled in an electric resistance furnace open to the air. The total time during which the maximum temperature was maintained was about fifty hours. A rather extreme test has been applied to this same piece lately, by heating it to about 900 deg. Cent. and plunging it into cold water, after it had cooled to a dull red. This has been repeated three times and the surface shows no signs of cracks or any tendency to scale.

Fig. 2 shows a similar comparison between two pieces of sheet iron tube, one calorized and the other not, which were both subjected to a temperature of 800 deg. Cent. in a gas furnace for 100 hours. The uncalorized piece is practically destroyed, while the calorized piece is unharmed.

As evidence of the performance of calorized iron under actual working conditions, the tubes shown in Fig. 3 were photographed. These tubes are part of a small nitrogen purification plant which is in use during each working day. They are both heated by gas in a brick furnace, the larger tube to a temperature of about 800 deg. Cent. and the small to about 650 deg. Cent. The larger tube was calorized and has been in use over 400 hours with no observable deterioration, while the smaller tube, which was not calorized and which has also run 400 hours, is badly burned. The spots on the calorized tube are carbon deposits due to poor combustion in the burners. In Fig. 4 are shown these same tubes after they have run over 650 hours. The calorized tube still shows no evidence of scale while the other tube is almost burned through.

Another application of this process is to iron wire or ribbon such as is used in electric heating units. An untreated piece of this ribbon will burn out in four or five hours at the most, whereas tests upon calorized pieces have shown that the life is increased at least fifty fold, and in the best instances over one hundred fold. The results of tests made at Pittsfield indicate that a life of over 500 hours may be expected from calorized heating units run at a temperature of 800 deg. Cent.

Calorized seamless iron tubing is being used for combustion tubes in the research analytical laboratory where pure oxygen is brought in contact with the metal at temperatures from 900 to 1,000 deg. Cent. These have thus far operated all right and still appear unaltered after nearly 100 hours' use.

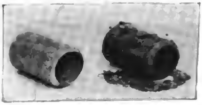


Fig. 2.—Effect of 800 deg. Cent. in a gas furnace for 100 hours on a section of calorized and of uncalorized sheet iron tubes.

The above facts seem to indicate that this is a simple method for extending the use of iron under oxidizing conditions at high temperatures, and for greatly prolonging the life in those instances where it is now used, but must be renewed at frequent intervals. In the case of small muffles or crucibles, where temperatures are below 1,000 deg. Cent., this treatment of cheap cast or wrought iron shapes seems very promising. While the life of the coating depends on the temperature at which it is used, as well as on the duration of time taken in its preparation, i. e., the quantity of aluminium which alloys with the surface of the iron, it does not permit of long use at temperatures much in excess of 1,100 deg. Cent.

Copper parts also, which are exposed to high tem-

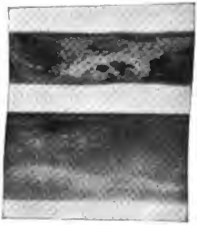


Fig. 4.—Photograph of the same tubes as shown in Fig. 3 (upper uncalorized), but after 650 hours at operating temperature.

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* From the *General Electric Review.*

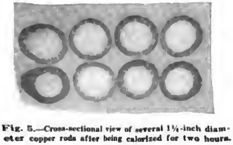

Fig. 5.—Cross-sectional view of several 1¼-inch diameter copper rods after being calorized for two hours.

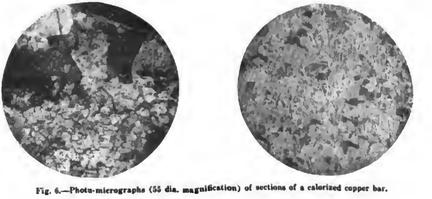

Fig. 6.—Photo-micrographs (55 dia. magnification) of sections of a calorized copper bar.

peratures, can have their life increased by calorizing. In some cases calorized copper may be used advantageously in place of aluminium bronze. For instance, a large power station had trouble from early corrosion of its condenser tubes. These tubes were aluminium bronze and were supposed to last at least a year. As a matter of fact, while occasionally tubes would last as long as six years, other tubes would fail in four to six weeks after they were installed. About two and a half years ago a set of calorized copper tubes was installed and so far not a tube has failed.

In some cases the life of copper contacts can be increased by calorizing. For instance, a set of railway controller contacts which were calorized showed double the life of the ordinary untreated contacts.

As has been said, the effect of calorizing is to produce a surface alloy containing aluminium. The thickness of this alloy varies with the length of time to which the piece is subjected to the calorizing process, and the percentage of aluminium varies through the coating being greatest at the surface. This is shown clearly by a cross-section of a calorized copper rod. The line between the alloy and the unchanged copper is sharp, but the color of the alloy varies from a rich golden-yellow next to the copper to a silvery-white at the surface.

Fig. 5 shows cross-section views of a number of copper rods 1¼ inches in diameter, which were calorized for about two hours.

Fig. 6 shows two cross-sectional photo-micrographs of a calorized copper bar. These photographs are magnified fifty-five diameters. One of them shows the large crystals of the calorized surface, and the other shows the unaltered crystalline structure of the copper a short distance below the surface. In the first of these photographs the blistering of the copper immediately below the calorized surface is shown by the spaces between the crystals of copper. This effect is characteristic of calorizing.

Fig. 7 shows cross-sectional photo-micrographs magnified forty diameters of an iron pipe which was used for some time as a heater for calorizing wire by the continuous process above mentioned. This pipe was packed with calorizing mixture, and its inner surface was therefore subjected to long calorizing treatment.

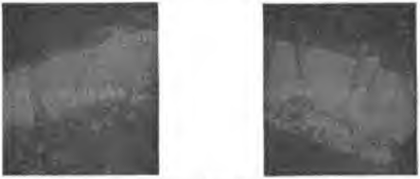

Fig. 7.—Photo-micrographs (40 dia. magnification) of sections of an iron pipe which has been subjected to calorizing action for a long period.

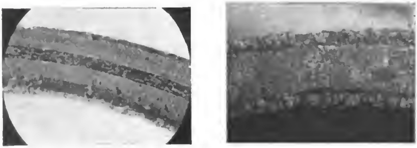

Fig. 8.—Photo-micrograph (20 dia. magnification) of cross-sections of an iron tube calorized at high temperature with a mixture rich in aluminium. Left-hand view, before heating; right-hand view, after heating at 1,100 degrees for 50 hours.

If the calorizing process is conducted at a high temperature in a mixture rich in aluminium, two layers of different alloys may result. Fig. 8 shows photo-micrographs, enlarged twenty diameters, of a cross-section of an iron combustion tube thus calorized. The first figure shows three layers, or rather five. The outer layers are probably mostly aluminium with a little iron, the next aluminium and iron with the iron predominating, and the middle layer the unchanged iron. The lines bounding the middle layer are especially sharply defined. The second figure shows the same tube after heating in the air at 1,100 degrees for 50 hours. The sharp lines bounding the middle layer have disappeared and the crystals now have a radial structure. This is characteristic of all samples fired at this high temperature, and is due to a diffusion of the aluminium into the iron, making a more homogeneous structure. The outside layer is still distinct, however, and this is probably due to the oxidation of the aluminium.

When an iron pipe or ribbon is calorized for a heating unit, a portion of the iron becomes alloyed with the aluminium. Naturally this results in changing both the resistance and the temperature coefficient. The thicker the calorizing coat the greater is the change. This is shown by the following table, in which No. 1 was given a lighter coat than No. 2.

Sample.	Ohms per M. (10°)	Temperature Coefficient Electrical Resistance (0–130°) × 10³
Iron Ribbon.	0.905	5.61
Same calorized, No. 1.	2.45	1.72
Same calorized, No. 2.	7.6	0.151

A thin ribbon may easily be calorized all the way through, and then becomes quite brittle.

The dimensions and weight of either a copper or iron piece are slightly increased by calorizing. The increase of dimension is much less than the thickness of the alloy coat, the greater part of which simply takes the place of the original metal. The dimensions may, however, increase several mils, and there is a tendency to a greater increase at the edges than on flat surfaces.

For iron, calorizing is intended only for protection at high temperatures. It does not compete with galvanizing, sherardizing, and other similar processes for protection against oxidation or corrosion at low temperatures. Its usefulness lies within a range of temperature much higher than a galvanized or sherardized coat could stand. For copper, calorizing is effective against corrosion at low temperature as well as against oxidation at high temperature. The upper limit is determined by the melting point of the alloy, which is somewhat lower the heavier the calorizing treatment, since that means an alloy with a higher aluminium content.

The probable explanation of the effect of the aluminium in the surface alloy is that a thin coat of alumina forms which prevents further burning of the metal beneath.

The Resistance to a Ship's Motion*

As Determined Experimentally by Means of Models in Special Tanks

In no other branch of the highly developed art of shipbuilding are the results of scientific observation so important as they are in the determination of the resistance opposed by the water to the vessel's progress.

This resistance determines the form of the hull and the power required to maintain a given speed. The laboratory of the chemist or physicist finds its counterpart in the experimental basin in which the shipbuilder tows small models of vessels and measures the resistance opposed to their motion.

Such experiments were less needed in the days of wooden sailing vessels because the best forms of hulls had been determined by the experience of centuries. The wooden sailing ship attained its highest development in the swift clippers of the middle of the nineteenth century.

The introduction of iron as the material of construction, and steam as the motive power, made it necessary to study closely the influence of the form of the hull upon the resistance, and to establish exact relations between engine power and speed.

The problem of resistance, however, attracted the attention of scientific pioneers 250 years ago. Newton, Bernoulli and Euler attempted to solve it, but their results were too greatly at variance with those of experience to have any practical value.

In the year 1770 the French Academy of Sciences appointed a commission composed of Bossert, Condorcet, and d'Alembert, to collaborate with Borda, who had been working on the problem seven years, in the establishment of a formula for the construction of a hull of minimum resistance. The possibility of discovering a mathematical formula applicable to all conditions of length, width, and speed was generally assumed during the succeeding one hundred years, and this view, though disposed long ago, is still often expressed.

Admiral Shévenard, following Borda's example, experimented with prisms, cylinders, and other simple forms. Subsequently (1775 to 1794) the Swedish engineer, Chapman, investigated the variation of the resistance with the position of the greatest cross-section in solids of rotation, 25 inches long, with paraboloidal and conical ends, but his researches produced no results of value.

A few years later (1793 to 1798) the English colonel, Marc Beaufoy, experimented with floating and submerged bodies in the Greenland dock, London. These experiments mark the first rational attack upon the problem, and it is interesting to compare the means employed with the highly developed apparatus and methods of the present day. A contemporary drawing of Beaufoy's apparatus is reproduced in Fig. 1. The power required for towing the model through the water was furnished by the fall of a heavy weight from a scaffold about 60 feet high. The motion of the falling weight was transmitted to the tow line by a multiplying train of pulleys, while the time and velocity of fall were measured automatically by the trace of a pendulum on a bed of sand. The models were made of wood, and were painted, for Beaufoy's first object was to determine the frictional resistance.

Many experiments of the same general character were subsequently made, especially in France, with models and even with ships, but all of these researches started from false premises.

It was found that the total resistance experienced by a vessel is much greater than the skin friction, and it was assumed that the difference is determined by the quantity of water which is thrust aside by the moving vessel. The celebrated English shipbuilder, Scott Russel, was the first to find the true cause of the discrepancy, in the formation of waves at the bow, and of waves and eddies at the stern of the vessel.

With the rapid development of steam navigation the resistance to motion, and the form of hull best adapted to minimize that resistance, assumed an importance that may be estimated from the fact that, for a given size and speed, the well designed ships of to-day develop only half as much resistance and burn half as much coal as the ships of thirty years ago.

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* Translated from Prof. Hermann Wilda's article in *Die Umschau*.

The first really scientific attempt to solve the problem was made in 1870, when the elder Froude began his celebrated experiments with models geometrically similar to the vessels which were to be built. Scott Russel, the most famous shipbuilder of his time, asserted that the resistance experienced by real ships could not be correctly deduced from such experiments, but Froude found that the 878-ton sloop "Greyhound," when towed at various speeds and drafts, developed resistances that agreed exactly with the results obtained with a model having one sixteenth the linear dimensions of the sloop. The conclusions that Froude drew from his experiments, on the basis of the laws of similarity that had been enunciated by Newton, are still of practical validity as they undoubtedly agree very closely with the facts.

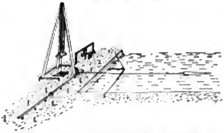
Fig. 1.—Beaufoy's apparatus for measuring the resistance opposed by the water to the motion of vessels.

In order to obtain correct results the weight of the model and the speed with which it is towed in the experimental basin must bear certain definite ratios to the contemplated speed and tonnage of the ships. For example, a model of the "Imperator," constructed on the scale of 1 to 50, must weigh 368 kilogrammes, a result obtained by dividing the displacement of the "Imperator," 46,000 metric tons, by the third power of 50.

The proper speed for the model, 1.73 meters per second, is obtained by converting the vessel's speed, 24 knots, into meters per second, and dividing the result by the square root of 50.

Several plans are drawn for the projected ship, and models constructed according to these plans are tested in the experimental basin in order to ascertain which develops the smallest total resistance.

The models are made of paraffin, to which a little wax is added. The mixture is melted in a water bath and poured into clay molds, with cores, producing hollow vessels with walls about two inches thick (Fig. 2). After the model has cooled it is taken from the mold and placed, in an inverted position, on the carriage of the shaping machine (Fig. 3). In this machine the model is moved longitudinally beneath two cutting wheels *n n*, which turn on vertical shafts *s s*, equidistant from the median plane of the model. The cutting wheels, as the model moves lengthwise beneath them, are gradually raised or lowered by means of their connection with an arm resting on the guide *w*, which represents a longitudinal vertical section of the vessel, at a certain distance from the median plane. For reasons of economy and convenience, the dimensions of the guide *w* are made smaller than those of the model. The table *t*, which carries the guide, moves in the same direction as the model, but less rapidly, and the guide arm is connected with the cutting wheels by a pantographic or magnifying mechanism. In this way two symmetrically situated longitudinal sections of the hull are outlined by the grooves made by the cutting wheels. The cutting wheels are then moved toward or away from the median plane, by turning the hand-wheel *h*, the guide form appropriate to their new position is substituted for the one already used, and the operation is repeated. On leaving the shaping machine the model presents the appearance shown in section in Fig. 4. The form of the finished model is represented by the bottoms of the grooves. The superfluous material, shown in black in Fig. 4, is removed by hand. If the model, when ballasted with bags of shot to the proper draft, has the calculated weight, it is ready for use in the experimental basin.

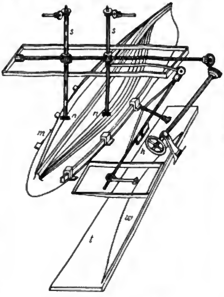

Fig. 3.—The shaping machine.

The basin (Fig. 5) is 40 or 50 feet long and flanked by heavy rails, which support the towing carriage *W*. All of the measuring apparatus is placed on this carriage, which bridges the basin and can be moved at various speeds by electric power.

The apparatus for measuring the total resistance to progression, is indicated in Fig. 6. The model is attached by a tow line to one arm *c* of the iron frame *a b c*, which is pivoted to the towing carriage at *o*. The opposite arm *a* is attached to one end of the dynamometer spring *f*, the other end of which is fastened to the carriage. As the carriage moves, from right to left, the model is drawn through the water in the same direction. The resistance of the water produces a tension in the tow-line, which turns the frame *a b c* about the pivot *o*, and stretches the dynamometer spring *f*. This displacement is multiplied by ten by an aluminium lever pivoted at o_1. The long arm of this lever, one meter in length, carries a tracing point *s*, which presses upon a rotating cylinder. The curve of resistance, thus traced, is a straight line if the speed of the model is kept constant and all shocks are prevented. The function of the spring f_0 between the model and the tow-line, is to equalize the tension and compensate the oscillations of the model. Records of the distance traveled, in five-meter spaces, and of the elapsed time in half-seconds or quarter-seconds, are simultaneously inscribed on the cylinder by appropriate mechanism. The strength of the dynamometer spring, which must be selected in accordance with the size and speed of the model, is measured by weights suspended from the arm *b*. As the three arms, *a b c*, are equal in length, the effect of a weight suspended from the end of *b* is equivalent to that of a force equal to the weight, applied horizontally in the proper direction at the end of *a* or *c*. (The weights *p* are not used in the towing experiments). The apparatus employed for the measurement of resistance in different experimental basins varies in detail, but all of it is based on the same fundamental principle, which was enunciated by Froude.

The force required to drive a screw-propeller, and the pressure exerted upon its blades by the water, are also determined by experiments with small models in basins. The apparatus employed for this purpose is indicated in Fig. 7. The propeller *p* is carried by the frame *a b c d*, which can turn freely on the pivot *o*. The end of the arm *a* is connected with the lever *h*, and the pressure on the propeller is compensated approximately by placing weights *q* in the pan *s*, suspended from the top of the lever. The compensation is completed by the spring *f*, at the end of the horizontal rod *t*, attached to the upper part of the lever. If the compensation is not exact, the lever *h* departs from its vertical position and strikes one of the electrical contacts *k k*, thereby causing the electric motor *m* to rotate forward or backward, and to compress or extend the spring *f* by means of the screw *g*, until the lever is brought back to its position of equilibrium. The pressure on the propeller can then be computed from the weight *q* and the change in the length of the spring *f*. As the contacts *k k* are very near each other the lever *h* cannot depart far from the vertical, and the tracing point *i*, attached to the rod *t*, inscribes a nearly straight line on the recording cylinder. At the same time the torque of the propeller is measured by a torsion dynamometer intercalated in the shafting by which the propeller is driven.

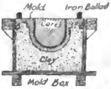

Fig. 2.—The model in its mold.

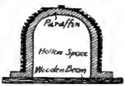

Fig. 4.—The model as it leaves the shaping machine.

The newest experimental basins are equipped with apparatus for making continuous photographic records of the waves formed by the bow and stern of the moving model.

There are now in existence twelve experimental basins of this general character; two in Germany, four in England, two in the United States, and one in each of the countries France, Russia, Italy, and Japan.

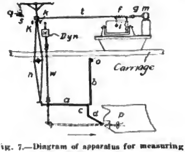

Fig. 7.—Diagram of apparatus for measuring pressure of propeller.

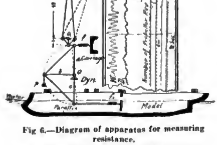

Fig 6.—Diagram of apparatas for measuring resistance.

The insert shows the record on the cylinder, where *W* is the resistance to progression, and *D*, pressure on the propeller.

What an Incompetent Workmen Costs

It has been stated that the records of a large manufacturing plant show that it costs on an average $35 to engage a workman, try him out and discharge him for incompetency; and while this is undoubtedly an expensive experiment in ordinary machine work, it will be readily apparent that it may be vastly more so in the case of a power plant, where an incompetent shift engineer might easily cause great damage in case his inefficiency was not discovered before some emergency arose which he was unfit to handle. It is evident that in a large plant a great deal of money may be wasted annually if proper care is not exercised in taking on new men, and to avoid this the personal attention of some experienced man will go much farther than the formal red tape method of having a cheap clerk sort over a miscellaneous collection of complicated "employment statements" which many a first-class workman may not be able to fill in properly.

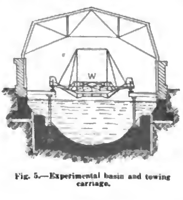

Fig. 5.—Experimental basin and towing carriage.

Producer Gas from Low Grade Fuels*

Cheap Power from Fuels Not Heretofore Considered Economical

The Reports of the U. S. Geological Survey show that, if the rate of increase of fuel consumption in this country that has held for the past fifty years is maintained, the supply of easily available coal will be exhausted before the middle of the next century. The production of coal in the United States increased from less than twenty million tons fifty years ago to nearly five hundred million tons in 1912; if the industries of the country continue to develop at a sufficient pace to maintain this rate of increase, then the limit of our coal supply will be reached in about 200 years. As a matter of fact, the fuel consumption per capita is actually increasing much faster than the population, so that the question of the continuation of this rate of increase is one of considerable importance.

It is interesting to note that the production of coal in the United States has been for some years greater than that in any other country. The world's production of coal by countries for 1907—the last year for which figures are available to the writer—is given in Fig. 1.

The disposition of the coal fields in this country, as well as the relative areas of the different grades of coal, is indicated in Fig. 2. The limited supply of good coal makes it necessary to mine large quantities of sub-bituminous coal and lignite to meet future conditions. It will be noted that there is very little over-lapping of the bituminous and lignite areas.

Most of the United States lignites do not weather well, but break down and crumble into fine dust when exposed to the atmosphere for any length of time. There are, however, extensive areas of lignites in Alaska which stand up very well under weather conditions.

A great many low-grade bituminous coals and lignites may be utilized for power purposes by briquetting, and the use of this process industrially is gradually increasing. Briquetting, however, raises the price of the fuel by a considerable amount. It costs 90 cents to $1 per ton to briquette coal, and this large expense is practically prohibitive in competition with cheap fuel. On account of the expense, it appears that briquetted coal will hardly become adopted for large plant work, though this form of fuel undoubtedly serves well under certain conditions for domestic purposes.

Another low-grade fuel is peat. There are large deposits of peat in this country, and in Canada there are some 37,000 square miles of peat area from six to ten feet in thickness. Peat is prepared in Sweden, Denmark, Germany and Russia, and is also secured extensively in Ireland and some parts of Holland. The distribution of peat in the United States is shown in the map, Fig. 3.

When it comes from the bog, peat contains about 85 per cent water, but when "commercially dried" by exposing it to the sun, it contains from 25 to 30 per cent moisture. Commercially, dry peat has a heat value of about 8,000 British thermal units per pound, and is very suitable for use in gas producers, as very little or no steam need be introduced with it.

In view of the necessity of utilizing, for the production of power, grades and varieties of fuels which have not until recently been considered economical, the U. S. Bureau of Mines has conducted a number of investigations on the making of producer gas from such fuels.

The introduction of the gas producer into this country for power plant work was made about the year 1900. In that year the number of installations was very few—perhaps two or three plants—but since then it has steadily increased. The total number of plants in 1911, of which the writer has record, was 660, and of these a large portion were double installations, which were not counted separately. The number of gas producer power plants in the United States at the present time is probably in the neighborhood of 1,000. The total horse-power of such plants in the United States in 1900 was 2,000; this has increased year by year until in 1911 it was between 160,000 and 170,000, some 80,000 of which was obtained from bituminous coal, some 70,000 from anthracite fuel, and about 10,000 from lignite.

Of the total number of plants operating in 1912, 84.5 per cent used anthracite coal and 10.7 per cent bituminous coal, while lignite was used in 4.4 per cent of the installations. The anthracite plants, however, represented only 47.8 per cent of the total horse-power developed, the bituminous plants 46.3 per cent, and the lignite plants 5.4 per cent, while wood and oil developed the remaining small percentage.

The anthracite plants are scattered all over the country, though several are congregated around New York and Philadelphia. The lignite plants are chiefly in Texas and Washington; there was a marked increase in 1912 in lignite plants in the former of these States. The largest total horse-power is produced in New York, and the next is Missouri.

Factors which influence the installation of any particular type of plant are cost of installation and of maintenance, and economy. The average cost of producer gas installations is about equal to that of reciprocating steam engines; the cost of maintenance is, however, only about one-half, while the economy has been shown in several cases to be from two to three times as great. These statements are illustrated in Fig. 4.

At the Interboro Rapid Transit Company's Fifty-ninth Street Station, New York city, is one of the most efficient steam plants of which the writer has knowledge. At this plant, 970 British thermal units have to be put into the furnace to realize 100 British thermal units at the busbars. In a theoretical gas plant devised on the same scale by Mr. Scott, Superintendent of Motive Power of the Interboro Rapid Transit Company, 100 British thermal units are obtained at the busbars when only 465 British thermal units are charged into the producer.

Representing the figures in the above example in percentages, out of 100 per cent of energy thrown into the furnace of the Interboro Rapid Transit Company's boilers, 10.3 per cent is realized as useful work at the busbars. The theoretical gas plant assumed for comparison would deliver 21.5 per cent to the busbars.

At the Bureau of Mines Testing Station, a 250 horse-power Corliss engine, with 26.6 pounds water rate, with Heine boilers, required 2,060 British thermal units charged into the furnace to secure 100 British thermal units at the busbars, while a gas producer and gas engine, using the same fuel, required only 740 British thermal units to deliver 100 British thermal units at the busbars. In other words, 4.85 per cent of the energy in the fuel charged into the furnace of the steam plant was delivered to the busbars, while 13.5 per cent of that charged into the producer was delivered in the same way.

From a series of tests on a number of different Illinois coals, a comparison of the quantity of fuel per horse-power hour required in the steam plant and in the producer gas plant at the Bureau of Mines showed that, on the average, the former required 2.6 times as much as the latter. With fuel ranging in heat value from 14,000 to 15,000 British thermal units per pound, the gas plant

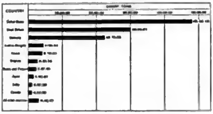

Fig. 1.—World's production of coal.

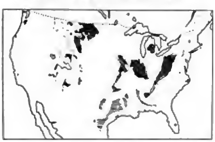

Fig. 2.—Distribution of coal fields in the United States.

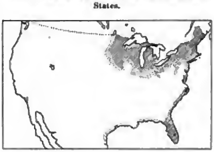

Fig. 3.—Distribution of peat in the United States.

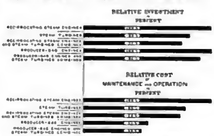

Fig. 4.—Comparative cost of steam and producer gas power plants.

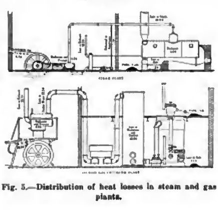

Fig. 5.—Distribution of heat losses in steam and gas plants.

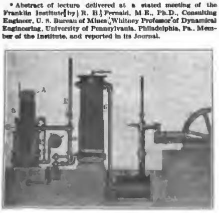

Fig. 6.—Simple form of suction producer.

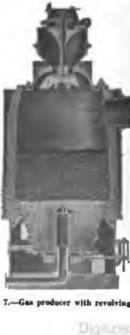

Fig. 7.—Gas producer with revolving grate.

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* Abstract of lecture delivered at a stated meeting of the Franklin Institute by R. H. Fernald, M.E., Ph.D., Consulting Engineer, U. S. Bureau of Mines, Whitney Professor of Dynamical Engineering, University of Pennsylvania, Philadelphia, Pa., Member of the Institute, and reported in its Journal.

consumed approximately one pound, and the steam plant approximately three pounds per horse-power hour. Similarly, with fuels ranging between 7,000 and 8,000 British thermal units per pound, the gas plant consumed 2¾ pounds per horse-power hour while the steam plant required 7 pounds. These figures represent the average of a large series of tests of coals and lignites from different sections of the country. The following results were secured under similar conditions at each of these plants.

Two and nine tenths pounds of West Virginia run of mine coal containing 2.4 per cent moisture per brake horse-power per hour were required in the steam plant, while the gas plant required but 0.85 pound of the same coal.

With New Mexican run of mine coal, containing 19.6 per cent ash, the gas plant required 1.1 pounds per brake horse-power hour, or just a little more than of the highest grade West Virginia coal, and very much less than the steam plant with West Virginia coal.

With West Virginia bone coal containing 44 per cent ash which came in such form that a great deal of it resembled rock and, when struck with a hammer, threw out sparks, only 1.66 pounds per horse-power hour were required.

Many such fuels as the above can be utilized in producer gas plants, which require, as indicated, much less coal per horse-power hour than the corresponding steam plant.

Lignites usually run high in moisture, but make a gas of excellent quality. Less lignite was required per horse-power hour in the gas plant than of West Virginia coal in the steam plant.

Fig. 5 shows the distribution of heat in typical steam and gas plants. The heat losses in the two plants are as follows:]

STEAM PLANT.	Per cent.	
Heat lost in ashes	2.00	
Heat lost in radiation and cooling	4.60	
Heat lost in smoke	24.60	
Total losses in boiler	31.20	
Heat lost in radiation and friction	3.30	
Heat lost in exhaust	53.50	
Heat lost in jacket water	....	
Heat lost in auxiliaries	7.30	
Total heat losses in entire plant		95.30
Net efficiency of plant		4.70

GAS PLANT.	Per cent.	
Heat lost in ashes	1.10	
Heat lost in radiation and cooling	18.60	
Heat lost in smoke	....	
Total losses in producer	19.70	
Heat lost in radiation and friction	4.30	
Heat lost in exhaust	23.70	
Heat lost in jacket water	33.50	
Heat lost in auxiliaries	....	
Total heat losses in entire plant		81.30
Net efficiency of plant		18.80

Original heat in the coal in both plants = 13,500 units per pound.

There are several types of gas producers now in use, among which are the suction type, the up-draft pressure type, the down-draft type and the double-zone type.

The suction producer is the simplest in form. A typical suction producer is shown in Fig. 6. The operation is as follows: The producer *B* is fed with fuel from the hopper *A*, which is provided with some feeding device so that the fuel may be dropped into the container below without admitting air. *C* is the vaporizer for vaporizing the water and mixing it with the air. The steam-saturated air passes down through the pipe *P* to the bottom of the producer. *D* is the starting fan. The hot gas leaving the producer enters a vertical pipe *E*, the upper part of which can be opened to the air to allow the poorer gas to escape when starting. ,The gas passes down the vertical pipe through a water seal to the coke scrubber *G*. Tar collects at the bottom of *E* and runs into the tank shown. From the scrubber, the gas passes into the expansion box *H*, from which it is drawn by the piston of the engine into the cylinder.

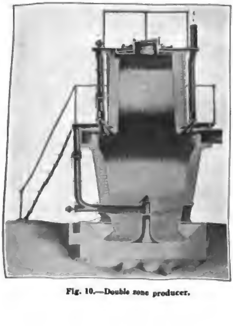
Fig. 10.—Double zone producer.

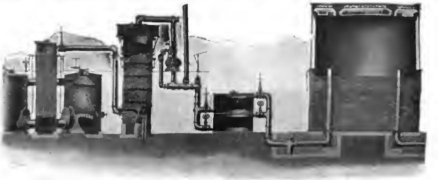
Fig. 9.—Producer plant that converts the tar into gas.

The gas produced by the use of air and carbon only has certain excellent qualities for power purposes, but is rather low in heat value, and further than that, in making such gas there is a tendency for the temperature to rise to such a point that excessive clinkering is produced and fuel troubles are caused. The introduction of water or steam maintains the temperature at a sufficiently low point to prevent clinker formations.

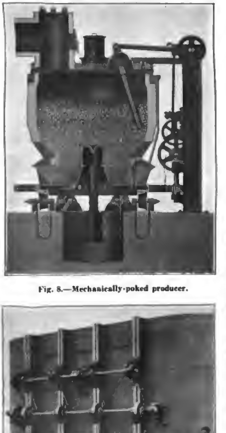
Fig. 8.—Mechanically-poked producer.

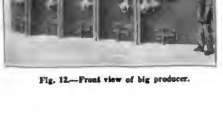
Fig. 12.—Front view of big producer.

When producer gas is made from coal, its constituents are carbon monoxide, a limited percentage of hydrogen and a small amount of marsh gas. Carbon monoxide is the main constituent.

Some gas producers embodying special features are shown in Figs. 7 and 8. The producer illustrated in Fig. 7 has a revolving grate and an automatic feed. That shown in Fig. 8 is a mechanically-poked continuous gas producer.

A number of gas plants are provided with centrifugal tar extractors, for removing tar. Getting rid of this tar after it is removed is a very serious problem, and many attempts are being made to effect an increased utilization of this product commercially. Fig. 9 shows a system in which arrangement is made for converting the tar into gas available for use in the engine. The method is to run two generators on a certain grade of fuel. The bed is a layer of coke; the fire is built on top of this and green coal is charged in over the fire. By this means an incandescent bed is formed. The draft produced by the exhauster draws the gas downward from the green coal through the incandescent bed, and the tarry compounds are supposedly converted into gas. The products are then drawn through the wet and dry scrubbers to the holder. As shown in the figure, the exhauster is situated between the wet and dry scrubbers.

With the above system, after a certain period of operation, the tarry compounds, dust, soot, etc., tend to clog the fuel bed and the pull on the exhauster increases. Under normal conditions, the average pull is from 5 to 6 inches of water, increasing steadily. When the pull has risen to about 20 inches, the process of "shooting the bed" is gone through. The charging doors and the gas valve are closed, and steam under 60 to 80 pounds pressure is turned on under the grate. This jet of steam shakes up the whole fuel bed and sends the dirt, dust, soot, etc., through the by-pass into the other gas generator. After the process is completed the gas has a heat value of about 200 British thermal units instead of 105 British thermal units.

A double purpose is served with this type of plant, as two kinds of gas are produced—the first being commonly called air gas and the second water gas.

The system is used by a company in Boston which, however, requires no water gas, but simply gas for the

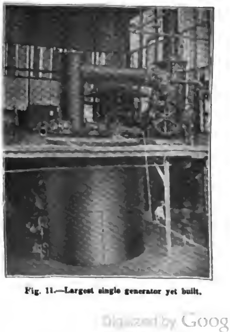
Fig. 11.—Largest single generator yet built.

engines. As a result, the bed is shot just as seldom as possible, sometimes not oftener than every six hours.

Another company uses a 4,000 horse-power plant of this type. This company requires about 2,000 horse-power for engine purposes, and the remainder of the gas for heating, tempering, annealing etc. In consequence, they shoot the bed just as often as possible, heating it up as rapidly as they can and then shooting it.

Tar can be satisfactorily converted into gas under the proper operating conditions. If, however, the temperature is not quite right, lamp black usually results.

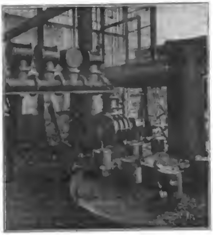

Fig. 13.—Tar extractor for big producer on charging floor.

In the type of plant described above, as the ash accumulates between the coke bed and the green fuel bed, the plant is intermittent and must be shut down in order to recharge. The charging door may be opened and the coal charged directly into the producer, the whole operation being in full view of the operator.

Fig. 10 shows a type of producer with a double zone, in which are run two fuel beds, the object being to get rid of the tar. The coke which comes down through the upper zone becomes the main fuel for the lower zone.

A plant which was installed in the summer of 1913, and which illustrates the latest type of producer, is shown in Fig. 11. This producer is installed in Illinois, and is the largest single generator producer in the world. The producer proper is of simple construction and is made out of sheet steel and channels. It has semi-cylindrical ends and flat sides, as shown in Fig. 12. The capacity of the plant is 40 tons of Illinois bituminous coal per 24 hours. The producer is equipped with what is known as the "Smith Type F Tar Extractor," having a capacity of 250,000 cubic feet per hour. This is not a centrifugal extractor, but consists of a double-tee arrangement; it has no moving parts and requires no water. The tar extractor in position on the charging floor is shown in Fig. 13. In this figure may also be seen the gas exhauster.

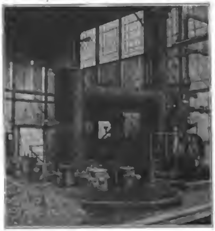

Fig. 14.—Charging floor of big producer, showing gas exhauster.

Fig. 14 is another view of the charging floor, showing the charging hoppers and the engine-driven gas pump.

Centralization will undoubtedly become one of the essential factors in producer gas work, and even now railroads are considering the question of installing large central plants at the coal mines and utilizing the fuel there. Many important advantages are to be secured by the installation of such large plants, not the least of which is the practical elimination of the smoke nuisance.

This alone is an important matter for consideration, especially in the case of plants located in large cities, for municipal regulations for the suppression of smoke are constantly becoming stricter.

Belgium's War Dogs

Convincing testimony to the usefulness of the dog has been supplied by the campaign in Belgium, our brave little allies employing large numbers for pulling machine guns and accompanying sentries on nocturnal duties. Curiously enough, this form of traction has only been adopted within the last year or two, and only fifteen months ago a Belgian Service paper wrote approvingly of the experiment, pointing out that, in addition to being docile and competent, the animals had become great favorites among the soldiers.

Among their advantages it was mentioned that they move silently, without apparent effort, over the roughest country, and that they are practically invisible a few hundred yards away. With striking prescience, the writer observed that the military Great Danes would be called upon to play a particularly effective and glorious part, little realizing probably how soon his words would become true. According to correspondents, the dogs have more than justified themselves. It is doubtful if their capacity is fully realized by those who have not studied the question. Over bad ice Arctic explorers do not hesitate to allot a weight of from 100 pounds to 150 pounds to each member of the team.

As it happens, the military authorities in Belgium must have found plenty of material ready to hand, since dogs are of considerable economic value in that country. Something like 175,000 are in constant use for drawing the small carts which to us are such a novel and conspicuous feature of life in Belgium. Butchers, bakers, milk vendors, small farmers—all have their dog teams. An early seventeenth century painting proves that the custom existed in those days, but it was not more than twelve years ago that a society came into being, the object of which was to encourage the breeding of a more powerful animal, to ameliorate the condition of those employed, and to replace those that die, free of charge to all owners who contribute the very moderate insurance premium of two francs annually.

Economists having estimated the daily worth of each dog variously from sixpence to a franc, it is easy to see how materially this canine army contributes to the wealth of the nation. The National Federation for the Breeding of Draught Dogs has a membership of over 2,000, and its operations are under the control of nine syndicates—one for each province. The Belgian and Provincial governments, recognizing the importance of the work, contribute annual subsidies to the Federation.

In that sad exodus from Antwerp it was interesting to read that the brave dogs were doing their part, dragging the effects of their hapless owners or easing the journey of children or old people.—*The London Daily Telegraph.*

Red as a Danger Indication*

The Value of Various Colors for Signaling Purposes

By William Churchill

Red is pre-eminently the color which, throughout nature, attracts attention, excites curiosity, and arouses to action. Nature does not make lavish use of the bright reds and scarlets in laying out her color scheme, but when she does employ those hues it is generally to bring about definite action.

Most naturally, therefore, when it became necessary in the development of railroad service to select a symbol of danger, red was the color chosen. In the course of time, green was adopted either for a clear or for a cautionary indication, and within the past twenty-five years yellow, blue, purple, and lunar white have been added to the list of recognized signal colors. In semaphore signals, European practice is confined mainly to the use of red and green. Here in America, where automatic signaling is far more extensively developed than abroad, the general practice ten years ago was red for stop, green for caution, white for clear. Of recent years most roads have adopted yellow in place of green for caution and made green the clear indication.

Whatever the system of signal indications, it is obvious that there is no place in active railroad service for any man with defective color sense or even with impaired vision, unless full correction can be made with suitable glasses.

Similar remarks apply to the marine service, but at sea the established system of signal lights makes less demand on the color sense than is the case in the railroad service.

The past ten years has witnessed a great increase in the use of red lights by night and red signs by day for a variety of warning indications entirely outside the railroad and marine service. Custom long ago fixed on the red lantern as the proper warning indication at an open ditch or other obstruction in a highway or public street. When automobiles began to multiply, it was quite natural that the red tail-light should make its appearance and soon be made obligatory by law. More recently still, public demand for better fire protection in hotels, theaters, and public halls has given rise to the habit of marking all exits by red lights; and now the movement for "Safety First," spreading from the railroads to industrial plants, has led to the widespread introduction of red signs or lights not merely for exits, but also to indicate dangerous parts of machinery, dangerous localities, high-power transmission lines, and the like.

This rapid increase in the general use of red as a cautionary indication obviously gives rise to the question as to what we are going to do to protect the color-blind individual for whom the red signs and red lights may be ineffective. According to the usually accepted statistics, about 4 per cent of all males and 1 per cent of all females are more or less color-blind, and in the great majority of cases red, or red and green, are the colors affected. Ought not a careful investigation be made to determine whether the ordinary red light or red sign is recognized as a danger signal by those afflicted with red-blindness? If not, can some special provision be made to cover all such cases as well as adapted to individuals with normal eyesight? With this thought in mind, a suggestion has recently been brought forward to adopt some other color or colors than red, e. g., a combination of yellow and blue, as a warning sign in industrial plants. The topic is surely a pertinent one, deserving of careful consideration, and should not be answered without much definite evidence, which seems to be lacking at present.

It is estimated that the solar spectrum includes about one hundred and fifty hues perceptibly different to the average eye with approximately thirty hues of purple lying between the two extremes of the visible spectrum. For signaling purposes it is obvious that a color should be as far removed from white or so-called "white lights" as possible; in other words, should have the highest possible degree of "saturation," or "purity," as it is frequently called, and should have the highest photometric intensity compatible with a proper degree of saturation. Furthermore, the colors selected must be sufficiently unlike in hue to leave little or no chance of possible confusion.

The Railway Signal Association specification recognizes six signal colors: red, yellow, green, blue, purple, and "lunar white." Of this list blue is the least satisfactory for reasons to be mentioned later, and is no longer used except in special instances.

The effective range of these colors under average weather conditions when used with the customary semaphore lamp and lens is approximately as follows:

Color.	Effective range.	Approximate transmission coefficient for standard semaphore lamp (oil burner)
Red	3 to 3½ miles	0.20
Yellow	1 to 1½ miles	0.35
Green	2½ to 3 miles	0.17
Blue	½ to ¾ mile	0.01
Purple	½ to ¾ mile	0.03
Lunar white..	2 to 2½ miles	0.15

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* Transactions of the Illuminating Engineering Society.

In actual service it is seldom necessary to see a signal more than 3,000 feet (914.40 meters), but a light of barely sufficient intensity to be visible that distance would never be feasible for an important indication. Volume of light is essential as well as correct hue, and it does not require very dense fog or smoke to cut the range of even a standard red signal down from three miles (4.82 kilometers) to a few hundred feet.

Time does not permit the writer to take up in detail the theory of color as it affects the selection of these six standard colors, nor to discuss the methods followed in laboratory study of the problem. Suffice to say that by repeated melts of all available glasses, spectroscopic analysis, photometric and service tests, the theoretical possibilities were narrowed down to six definite tints. Numerous service tests were absolutely essential since atmospheric absorption and reflection, which cannot be effectively simulated in a laboratory, produce certain definite changes in the appearance of all signal lights. All colors seen at a distance are shifted more or less in hue toward the red end of the spectrum. This effect is, of course, most apparent in fog, haze, or smoke; at times it is strong enough to make a dull green out of a blue light, a yellow out of a "white light," a red out of a yellow light.

A few remarks on each of the recognized signal colors may help to bring out some points of general interest.

Red.—To normal vision red is beyond all question the most effective color for a danger signal. It is quite true, of course, that the eye is far more sensitive to light in the middle of the spectrum than toward either extreme, but of much greater importance is the fact that as the apparent size of the source diminishes red never ceases to look red. Its chromatic and achromatic threshold are always the same. This is not strictly true of any other color, although a good signal green approaches close to such a requirement.

Red has the further advantage that the intensity of the light can be increased by the addition of a considerable proportion of reddish orange light (620-590$\mu\mu$) without a pronounced change of hue because the eye is not very sensitive to change of wave-length in that region. On this account red has the longest range of all signal colors. That advantage, coupled with the fact that so long as it is visible at all, regardless of distance, intensity, or atmosphere, a red light is always and unmistakably *red*, makes it the ideal color for a danger indication when color blindness can be disregarded.

Yellow.—Yellow at best is not an ideal signal color. Its chromatic threshold is much higher than its achromatic threshold; or in other words, it can be seen as a light of indistinct color much farther than it can be definitely recognized. This difficulty is, of course, greatly increased by the circumstance that most of the ordinary sources of illumination are more or less yellowish in predominant hue and hence liable to cause confusion. The yellow signal may be mistaken for a "neighborhood light" close to the right of way. Some reaction time experiments conducted by the author twelve years ago demonstrated quite conclusively that yellow required a longer time for recognition than red or green, and that yellow and white were frequently mistaken for each other.

The fact that atmospheric absorption may make a yellow signal appear reddish at times is unfortunate, but never a serious objection so long as red remains the danger indication. Experience on many railroads has proven during recent years that the red-yellow-green combination is distinctly preferable to the older combination—red-green-"white" provided standard colors are used throughout.

Green.—Green is the most effective signal color except red. It is usually somewhat below red in range, due in part to atmospheric absorption, but a bluish green (approximately 500 $\mu\mu$) gives very good results. Recently it has been found possible to increase the transmission of such a glass by 35 per cent over the present standard without any loss in distinctness of hue, and it is probable that this new modification will show results in range of visibility nearly equal to the present standard red.

Since red, yellow, and green are the three principal long range semaphore signal colors, it is important that all should have approximately the same intensity, so that no one color may overpower either of the others when displayed in more or less close proximity to it. But the sources of illumination generally used (oil or incandescent lamps) are far stronger in yellow light than in either red or green. This means, accordingly, that the transmission of the red and green glasses should be kept at a maximum, while the yellow can properly be somewhat reduced below the highest intensity possible to obtain.

Blue.—Blue and purple are short range indications because the proportion of blue and deep red contained in the light of the sources commonly employed is extremely small. Both these colors must, of necessity, transmit quite a proportion of bluish green light in order to secure even a moderate amount of percentage transmission and range. Blue light is so rapidly lost by atmospheric absorption and reflection that the color of the blue signal tends to become distinctly greenish with distance. On that account blue never gives a really effective indication and is now seldom used, having been largely supplanted by purple.

Purple.—In a standard purple signal glass, the proportion of bluish green light transmitted is offset by red from the extreme end of the spectrum. The result is a color verging on magenta and about equally distant on the color scale from both standard red and standard green. The chromatic aberration of the eye is strikingly apparent in viewing a purple lens at a distance of 100 feet (30.48 meters) or more. The light appears ordinarily as a purple spot with a halo of deep bluish light surrounding it. This effect is varied more or less by conditions of astigmatism, as is well known to ophthalmologists. Such a purple produces a signal indication which for distinctness compares rather favorably with the other colors. Unfortunately its use is restricted by the fact before mentioned, that its total transmission and range of visibility is low.

Lunar White.—While studying the problem of how to render the yellow signal more effective, the writer was led to the conclusion that a bluish white signal could be made useful as an additional indication and would, in some respects, be preferable to yellow. By means of a pale blue glass we are able to eliminate enough of the yellow in a kerosene flame or incandescent lamp to make the light appear almost white with a slight preponderance of blue. This new possibility was called "lunar white," and has come into use as a clear indication for switches on a number of roads. In actual service it has proven to be at least as distinctive a color as yellow and to possess longer chromatic range for most observers.

The established system of railroad signal colors briefly mentioned above is based on the assumption of normal color vision. But when red is used as a warning signal for the general public, the question naturally arises whether red-blind individuals are properly protected. It is reasonable to assume that about 4 per cent of all the drivers of automobiles and other vehicles are color-blind. Before the importance of eliminating color-blind men from railroad service was appreciated, it was morally certain that at times serious wrecks were caused by defective color sense. It is highly probable that at the present time some automobile accidents are due to the same cause, although definite evidence is very difficult to obtain. It is hardly to be expected that all automobile drivers could be compelled to pass a test for color vision. Neither is it fair to ignore the color-blind in establishing a standard warning indication for vehicle tail lights, highway obstructions, fire escapes, and similar purposes.

Should not a serious effort be made to determine by actual tests with a large number of color-blind subjects whether the present red signals furnish sufficient protection? It is reasonable to assume from what is known regarding the peculiarities of abnormal color vision that a red-blind individual will perceive the average red light as a yellow of some sort, and that the yellow in such case will be of low intensity. As the color exhibited tends toward orange, the hue is likely to become more distinct, and the intensity, of course, higher. A purple light probably appears blue to the red-blind subject, and is at times confused with green lights on that account. This is one of the frequent mistakes made by color-blind persons undergoing test. But either an orange-red or purple light presumably is much easier for the red-blind or red-green-blind to recognize than an ordinary red light. It would be a waste of time to speculate on this point, but a carefully conducted series of tests would soon bring some definite evidence to light.

If either a reddish orange or a purple proves to be distinctly better for abnormal color sense, a standard shade could easily be determined which would be entirely satisfactory for normal color vision. Incidentally there might be some advantage in utilizing a hue which would be somewhat different from the standard red of railway service. It is the constant effort in signalling practice to reduce the number of red lights visible along the right of way to a minimum, so that red may indicate only two possible conditions to the engineer's eye; a "high-signal" set at danger or a "tail light" at the rear of a train.

Parallel to the investigation respecting the perception of red lights by the color-blind, a study should be made of the best pigment color or colors to use for danger indications. It would seem desirable, in this connection, that a standard danger symbol be developed and made international, just as in the marine service all over the world green signifies a starboard light and red a port light. Such a symbol should be simple, but as distinctive as a red cross flag. Theoretically, a circular blue or orange band inclosing a red center would seem to fulfill all requirements. It would be more striking in appearance than any mere black and white sign and it would furnish a colored indication to all types of color vision except the very rare cases of total color blindness. Practically no instances are found where the color sense for both red and yellow or red and blue is lacking in the same subject.

Such a symbol and such standardization of practice concerning lights for danger indications in public places or industrial plants might render some real service in the cause of "Safety First" and would certainly eliminate one possible cause of unnecessary accidents.

Ben Franklin Vindicated*

The decline in popularity of lightning rods, following the pernicious activity of rascally agents, left a stain on the scientific reputation of the great and wise Ben Franklin, who developed this protection against thunder bolts. Scientists have stoutly defended the value of such equipment, if well put up, but, nevertheless, practical men, often speaking from bitter experience, have maintained continuously for generations that the rods have proved worse than useless.

Two valiant defenders of the faith, Profs. J. B. Reynolds and W. H. Day, of the Ontario Agricultural College, not contented with the inconclusive deadlock of theory and claimed fact, set out to find the truth—in practicable demonstrable form. For ten years, first one and then the other industriously collected all possible information about buildings reported struck by lightning in Ontario. At the end of this time (1910), they had data on 599 buildings struck by lightning. Of this number struck, 317 or 53.6 per cent, were burned, but only 18 of the buildings struck, or 3 per cent, had rods and only three of these, or 16.6 per cent, of the protected buildings were burned. Having these interesting but incomplete figures, the investigators desired to know further the number and experience with unrodded buildings in the province, so that they might complete their case—reasoning that if rods neither prevented nor induced strokes the ratio of damaged to undamaged structures in the unprotected risks would be of the same order of magnitude as in the rodded.

Great difficulty was found in securing the desired data. Eventually, however, the provincial mutual insurance companies were interested in the studies and reports covering about a fourth of the province were secured after some delay. These showed that 21 per cent of insured farm buildings were rodded and that of all those struck only 1½ per cent were rodded. Of 7,000 unprotected buildings, 37 were struck; out of 7,000 protected ones only two were struck. Therefore, 35 were saved out of 37 expected to be struck, or a probable protection of 94.5 per cent and that with uninspected rod construction.

Prof. Day visited Iowa and Michigan to inspect the insurance reports and methods of protection there. In Iowa, he found that the total claims paid for lightning damage in eight years amounted to $4,464 on rodded buildings and $341,065 on unprotected ones. Apparently then, for each dollar paid on rodded risks $76 was paid on unrodded. The rods were not inspected and some of the losses probably were due to poor construction. Even so, the protection shown was 98.7 per cent. In Michigan, one mutual company insuring only rodded and inspected buildings, in four years paid $82 claims on $55,172,075 risk. Another mutual company taking both protected and ordinary risks paid $32,209 in claims on a total of $59,567,272 in the same period. The loss was practically all on unprotected buildings aggregating $45,758,818 in value of risks. Comparing the two companies, for each $1 damage on protected buildings there seemed to be paid $1,168 on unprotected ones—an obvious protection of 99.9 per cent. All this and more is set forth at length in a recent bulletin of the Ontario Department of Agriculture.

Regarding the technique of the rod construction so successfully employed in these states, it is of interest to know that, where knowledge was available, there appeared to have been used more or less of an approach to a cage of conductors about the building. The rods were fastened both close to and away from buildings but without insulators. Deeply buried ground plates and rods were found and where these groundings proved defective there invariably developed disaster.

The worthlessness of the old lightning rods, of course, was the fault of the loquacious fly-by-night agent who carelessly put up his cheap affairs, gathered his money and disappeared, leaving disaster and ruin for many a farmer on the approach of the first heavy electrical storm. A deliberate campaign to discredit the great American philosopher and patriot could not have worked as well. It is a source of much satisfaction to see definite figures which substantiate the soundness of his scientific knowledge as well as that of a long line of later physicists.

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*From the *Engineering News*.

The New York Fire Alarm System

A History of the Past and Plans for the Future

By Putnam A. Bates, Electrical Engineer, Chief of Bureau of Fire Alarm Telegraph of the City of New York

The movement for an improved fire alarm system for the City of New York which the present administration has taken in hand, was started in December, 1904, when the insurance companies urged that a committee be appointed to investigate the situation and make a report of its findings.

In 1905, the New York Board of Fire Underwriters made a six months study of the problem and rendered a report condeming the present system as beyond repair. This investigation was limited to conditions on the island of Manhattan.

The following year the city itself took hold and in March, 1907, preliminary plans and specifications were prepared for a modern fire alarm system for the island of Manhattan, but there was no attempt to engage in the work of reconstruction until about four years later. Small appropriations were set aside for this much needed improvement as early as 1903, but these funds were largely diverted to keeping the old system in operation, and in the ten years which followed the money set aside for installing a new fire alarm system in all boroughs has aggregated the substantial sum of $1,609,000. That progress toward reconstruction has not been accomplished is a matter reflecting little credit, being born of no definite plan of procedure.

The preliminary plans required the building of the new system before the abandonment of the old. This course should have been followed, but unfortunately it was not, and the new contracts that have been entered into aggregate too small an amount for economic handling, and constitute patch work at high rate of cost.

I see no valid reason why the practical installation of a fire alarm system for a large city should follow a different course than that usual in important engineering operations of other character. There is a certain economic relation that must be maintained between the supervising staff, or overhead cost, and the scope of the work itself. Proper efficiency cannot result where this fact is disregarded, and my efforts during the past six months have been devoted largely to accelerating the work of bringing outstanding contracts to a close and to raising the standard of the bureau staff to a point where greater work can be handled with increasing ease.

The agreement by the city with the Empire City Subway Company in 1891 makes it mandatory upon that company to provide the city with such ducts as may be needed for the fire alarm wires in all streets and avenues where subways exist, or where there may be a demand for subways; thus the city will be able to install the modern fire alarm system without constructing subways, which offers an advantage in time as well as in cost. The saving will extend in like manner to the Bronx, Brooklyn, Queens and throughout the built up portions of Richmond, as it is proposed to pursue the same general plan in all boroughs.

In taking up this problem, my first inclination was to learn the disposition made of outstanding appropriations, and the extent of new work that had been undertaken, which I found to consist of the following: A new central station building for each of the three larger boroughs, Manhattan, Brooklyn and the Bronx; underground service cables for connection to 138 street boxes in Manhattan; similar underground installation connecting 199 boxes in Brooklyn; an important underground feeder line reaching to southwest Brooklyn; bridge cable connecting Brooklyn with Manhattan; underground service cables for connection to 119 boxes in the Bronx; a similar underground installation connecting 8 street boxes in Queens; a supply of 2,000 alarm post bases; a supply of 300 cast iron manhole frames, and concentrating subways leading to the new Manhattan Central Office building and the similar building in the Bronx respectively.

These contracts aggregate about one-third of the total appropriations made thus far, and all of them were in an unfinished state with the exception of smaller items, representing a total of about 5 per cent. The unencumbered balances were about equal to the aggregate of the contracts placed, leaving a remainder of about one-third of the total appropriations diverted to other uses, principally that of maintaining the old system.

This old fire department bell tower, still standing on a high point in Mt. Morris Park, Borough of Manhattan, is the last of twelve look-out stations located at places of advantage, such as the cupola of City Hall, and the public markets.

This method of sending alarms of fire New York city depended upon until 1870, when the system now in use was installed.

Before describing the present day conditions and plans I will refer to the early history of fire alarm telegraphy in New York City, from the beginning in the year 1865.

At that time the fire alarm plant consisted of twelve bell towers, or look-out stations, located at points of advantage, and the mode of operation was to watch for smoke or other indications of fire with a telescope and to signal by means of the Morse telegraph, directly to the central office. The signal was then communicated to the department by striking the bells at the twelve bell towers.

The central office at the City Hall was the terminus of four lines of wire connecting the Post Office, Essex Market, Union Market, MacDougal, Jefferson and 51st Street towers. In each of these stations was a main circuit magnet and bell, and a circuit breaking key. The signals indicating the districts in which the fire was located were sounded on these bells, with the numerical designation of the station giving the alarm.

The city was divided in eight districts, the first two being that part of the city above a line drawn through 22nd Street. In these districts the signals were struck on the fire bells by the bell ringers in the towers, and were the only guide the firemen had in locating a fire.

From the central office eleven lines radiated connecting the engine, hose and hook and ladder company houses below 14th Street, which, with the instruments placed in these houses, was known as the Robinson telegraph.

This primitive system was soon found inadequate, and in 1870 a complete new installation was made at a cost of $450,000, and including about 578 street alarm stations. The records of the department show that few difficulties were experienced for a period of ten years, in fact many decided improvements in its working were effected, and this installation is the basis of the present day fire alarm telegraph plant in the Borough of Manhattan.

We thus come to the year of 1881, and it is interesting to turn to the records following the storms of that year. The description of the damage to the fire alarm system that winter so closely resembles the conditions reported in March last, that I quote the exact phraseology as I find it in the year book of that time, as follows: "An extraordinary sleet storm occurred on January 31st rendering the fire alarm telegraph so nearly inoperative that at one time there were but six of the 578 street alarm boxes in communication with the central office, at headquarters, in consequence of the prostration of the wires. Since it became apparent that the telegraph would be endangered, street patrols were established in each company district for the discovery of fires; the communication of alarms to the companies required each response by mounted details; the discontinuance of all leaves of absence; ringing of the tower bells for fires and details of men from the upper to the lower part of the city."

This serious situation was followed by the passing of resolutions and much public comment, but history repeats itself and the public soon quiets down after a critical moment is past. It therefore is not surprising to find that the storms of 1888 and again of 1914 completely demolished the fire telegraph system not in Manhattan alone but in Brooklyn, Queens, the Bronx and Richmond.

It is a matter of experience that whenever serious trouble occurs, affecting many of the line wires, the alarm load goes up correspondingly. The fact makes the reliability of the alarm system doubly essential as it is during high winds, sleet and snow storms, or other circumstances likely to threaten conflagration that efficient operation is most needed.

Through sheer good fortune New York City has passed through three sensational moments when it would seem that only the protection of a higher power has saved it from great disaster.

In a large city like New York the operation of the fire alarm is accomplished manually. Many attempts have been made in the past to devise means whereby the full operation might be performed automatically, but so far none has been evolved which is feasible and safe for a large city. In the present installation there are two distinct classes of circuits: box circuits and engine house circuits. All street fire alarm boxes in the Greater City are operated on "closed circuit," in other words,

After the snow storms of March 1st and 2nd, 1914, mile after mile of wire and hundreds of poles lay upon the streets of the outlying boroughs.

The conditions were at their worst in the Bronx, Brooklyn, and Richmond where electric light, telephone, telegraph and fire alarm wires were tangled together in a hopeless mass. With the present "overhead" fire alarm plant, New York city is in danger of serious conflagration should a fire break out at a time when the telegraph circuits are inoperative.

current is constantly flowing and any interruption in this flow may be detected at once at the central office. In that way the operators at all times know the condition of their lines.

When a street box is "pulled" the clock work mechanism in the box rotates a disk having notches cut in its periphery, which causes a switch to open and close the circuit periodically according to a prearranged order or time interval. This operation causes a certain number of taps on a bell in the central office, and a corresponding number of dots on a register tape, which spell out the number of the box. Upon receipt of the signal the operator transmits it to the engine companies.

Manifestly the central office must be surrounded by every possible safeguard, as its security is vital to the success of the entire fire extinguishing forces. It was strongly emphasized in the preliminary plans that the central office of the fire alarm telegraph system should have the maximum degree of protection against hazards of every nature, and in order that it should occupy a place which would form an economic and safe center, it was recommended that the central office building for Manhattan should be located on Transverse Road No. 1 running through the southern section of Central Park, which is a sunken road, concealed from view; but the final disposition of the matter as the result of recommendations by the Department of Parks was to locate this building on Transverse Road No. 2. The fact that the building is in the park is an unquestioned advantage, but unfortunately this particular location is surrounded by hazards which will necessitate additional work to insure safety. It is obvious that the presence of a large body of water, such as now exists in the lower reservoir, approximately 150 feet north of the site selected for the Manhattan central office, is a hazard, as are also the presence of a 20 inch and 48 inch water main in the road immediately in front of the building and the gas mains which lie in the same street.

In Brooklyn and the Bronx the sites selected for the new central office buildings, were in public parks in each instance, but the hazardous conditions mentioned in reference to the Manhattan central office are not present.

In planning the locations for the street boxes, the general rule now followed is that a box will be found at every other corner. In some instances exceptions are necessary, but the tendency is to increase, rather than diminish, the frequency at which the boxes occur.

The fire alarm service to schools and city buildings must necessarily be treated as additional to the street box service, but in a similar manner.

It is the purpose of the present administration to place all new wires which form the fire alarm circuits underground as far as practicable, and the specifications adopted for these cables require that they should be composed of solid conductors of soft copper of a size corresponding to No. 16 B. & S. gauge. Each conductor shall be tinned, and insulated with a high grade vulcanized rubber compound, the thickness of the insulating wall being not less than 3/64 of an inch and 30 per cent fine Para rubber compound with mineral base will be required.

The central office equipment in the case of the three boroughs in which new buildings have been erected is yet to be designed.

The new installation will be so planned as to enable it to operate in accordance with the present routine of the companies and officers of the department, and to allow for sufficient flexibility so as to be readily adaptable to any changes that may in future be considered necessary.

The fire alarm equipment in the outlying boroughs is a matter of no small importance, especially in consequence of the enormous increase in the number of wires comprising the electrical systems, the majority of which are still carried overhead on pole lines. The interference of electric light wires with those of the fire alarm telegraph is a source of constant menace. In a number of instances on record, street alarm box circuits have for hours been rendered useless through the destruction of the electrical mechanism of the boxes due to the crossing of conductors with wires carrying heavy currents of high potential. The danger of such interference need hardly be stated, though it will bear reiteration to say that the first seconds after the outbreak of a fire are of incalculable importance to the fire department, and anything tending to deprive it of the quickest method of getting such notice may carry with it most disastrous and ruinous consequences.

The only manner in which this constant source of difficulty may permanently be eliminated is by the laying of all conductors underground. This is the chief problem incidental to the completion of modernizing New York City's fire alarm plant, and measures must be taken to proceed with the extension of the underground system in such manner as will enable the work to progress under a uniform plan and not by piecemeal.

The transferring of the circuits to the subways, which was begun on the island of Manhattan as early as 1888, has to some extent been continued each year, but at entirely too slow a rate. The work has been prosecuted under many disadvantages, however, and the appropriations have been adequate only for small extensions. The work has also been delayed through the impractical procedure of attempting to make these extensions before a complete plan for the entire undertaking had been prepared.

In past years, the city has availed itself of the opportunity offered to attach its wires and cables to the elevated railroad structure and while this method served its purpose to a large degree, it was at the best a makeshift. It was regarded at the time as the best and cheapest method of providing a support for cables, and at the outset the cost of maintenance was small, due to their being less liable to mechanical damage, and the ease with which troubles could be found and removed. This, however, was when the elevated trains were operated by steam, and the third rail carrying electric current of high potential was not present. The dangers from the power current, and the excessive deterioration which has taken place in these cables, has caused this installation to be regarded as one of the most unreliable elements in the fire alarm system at the present time.

With the consolidation of the five boroughs into the greater city, the problems and difficulties of a better fire alarm service became greatly increased, as the outlying boroughs had merely a semblance of a fire alarm system, and this of a most inadequate character.

It is interesting to note the manner in which the fire alarm system in the Borough of the Bronx came into being. When the last attempt was made to modernize the fire alarm system in New York City in the year 1870, covering at that time the island of Manhattan, there were 700 boxes installed upon 50 circuits, and subsequently these circuits were extended to the present Borough of the Bronx, and some 300 boxes added thereto. Since then from time to time new boxes have been added until these original circuits were carrying a total of 1,350 alarm boxes, with the result that some of the circuits were too great in length, and all were so overloaded as to militate against their efficient operation. This condition has been relieved in a measure from time to time through the construction of additional lines, but the bad planning of the original installation is evidenced by unfavorable conditions which are still in existence. The Borough of Brooklyn has suffered to an even greater extent through this same difficulty, and is in a serious condition in this respect at the present time. In like manner the circuits in the Borough of Queens and Richmond are carried for great distances, and serve many more boxes than would be considered proper with a modern installation.

The entire extent of the circuit mileage including both the underground and overhead wires aggregate in the five boroughs between 3,500 and 4,000 miles, and it will be seen from this that the more substantial the method of installing these conductors, the less will be the cost to maintain them.

The problem, therefore, is to create as promptly as possible an adequate cable plant that will provide for such future growth as may be necessary and which will efficiently operate under present service requirements. These cables when installed in the existing underground conduits will provide the most important single item of a complete modern system. The system in the various boroughs is at the present time so antiquated as to be virtually a disgrace for such a municipality as New York City to own. Some of the original apparatus installed from 1865 to 1870 is still in service, and it is safe to say that with the exception of the central office of the Borough of Queens, and similar installation in the Borough of Richmond, the entire telegraph system of the greater city is obsolete.

The line plant in the various boroughs is inadequate and unsatisfactory. Seventy-five per cent of the area of Manhattan relies for protection upon two cables on the elevated structure, which are exposed to constant danger of destruction. In the other boroughs, overhead construction is almost exclusively used, so uniform plan or system in routing of the various lines has up to this time been adopted, and as a consequence there is an intricate net work of interlaced circuits difficult of supervision and maintenance. The lack of system in the planning of the cable plant in the various boroughs is probably responsible for not only more than one-half of the troubles encountered, but also for the maintenance of fifty per cent more wire than would be necessary, if the most direct routes had been followed.

A brief statement of the scope of the new plans as they are now being prepared undoubtedly will be of interest, and I will include sufficient details to give a practical idea of the character and extent of the equipment proposed for each borough.

MANHATTAN

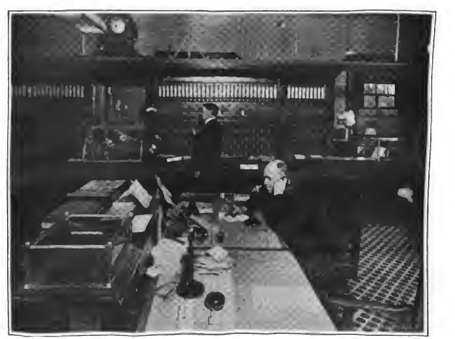
The plan of street box locations provides an installation of approximately 1,650 fire alarm box posts, so spaced that a person will not have to travel more than 400 feet from any point to the nearest fire alarm box, and in many cases, especially below Fulton Street, this distance will be much less. It is proposed that all of the feeder and distribution wires shall be in cables laid underground, which insures the greatest protection against interruption as well as maximum life.

THE BRONX

The new work proposed for this borough will be of such character as to constitute a ten year improvement. The majority of the feeders will consist of cables entirely underground, as well as a large proportion of the distribution circuits owing to the availability of conduits which have been or will be provided by the commercial subway companies.

BROOKLYN

It is proposed to provide a permanent installation for one-third of this borough, as the vast extent of the borough in itself makes the planning of a modern fire alarm installation a very difficult and expensive problem



Fire Alarm Telegraph Bureau Central Office at Fire Headquarters, Borough of Manhattan.

Showing the alarm box circuit switchboard and receiving instruments. From twelve o'clock midnight until eight in the morning two fire telegraph operators watch over the lives and property on Manhattan Island, and the protection of the borough from the spread of fire depends largely upon the alertness and accuracy of these two individuals.

unless taken up in sub-divisions, and the problem for each solved according to local conditions, owing to the relatively undeveloped character of the property on one side of the borough as against that of the other. Along the water front from Newtown Creek to and including Coney Island, valuable property and many lives are at stake to-day through inadequate fire alarm protection, and in this important section it is contemplated to install, as promptly as appropriations can be obtained, a modern system. This installation will be extended to include practically one-third of the entire area of the borough, leaving the remaining portion to be treated after the first undertaking is well under way.

RICHMOND AND QUEENS

These boroughs present quite an undeveloped aspect when compared with the other boroughs and, except for those extensions which are needed to rectify unsafe conditions, it is not my intention to prepare plans at this time for extensive improvements. However, a considerable number of additional boxes will be installed and the circuits in the well built up sections are to be laid underground in cables of sufficient capacity for the growing needs of the territory served for many years.

The cost of installing the complete fire alarm system in all boroughs, I have estimated at $3,000,000. However, to carry out the plan on the basis of the recommendations I have recently submitted to the Fire Commissioner would involve an immediate expenditure of approximately $2,000,000, and this installation when completed would result in a material reduction in the cost of maintenance, and would vastly increase the protection to life and property through the improved reliability of the fire alarm service.

Stereoscopic Drawing[*]

A Training for Accurate Workmanship

By Charles E. Benham

If a test were required for the accurate workmanship of a student in mechanical drawing, no better one could be devised than to set him the task of representing an object in perspective as seen by the right and left eye respectively. The two drawings, when placed in the stereoscope, should show a perfect effect of solidity; but the slightest deviation from exactness in either drawing would manifest itself in the stereoscope very distinctly, and there are few amateurs whose first attempt would not be a failure.

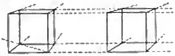


Fig. 1.—Showing method of stereoscopic drawing.

The dotted lines represent the pencilled construction lines.

By care and practice, however, very good results may be obtained; and for many scientific diagrams, in which a three-dimensional representation is necessary, stereograms are very useful, and may be substituted with advantage for clumsy models. As examples may be mentioned the forms of crystals, the imaginary planes that have to be explained to students of perspective, the diagrams required to illustrate the polarization of light, reflection, refraction, and other branches of optics, or, for speculative students, the mysteries of the hypercube.

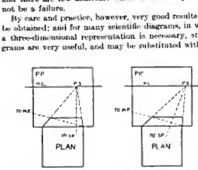


Fig. 2.—The left-hand figure shows the ordinary perspective paper as figured in the text books.

How the diagram should be thought of by the student is revealed by the stereoscopic view.

A difficulty occurs in the limited field allowed by the refracting stereoscope. This necessitates rather small drawing, and, as the lenses of the instrument magnify, the smallest errors are unpleasantly enlarged. Moreover, to avoid distortion, it is desirable that a perspective drawing should come within a horizontal angle of sixty degrees, and a vertical angle of not more than forty-five degrees, which, again, seriously limits the scope of the drawing.

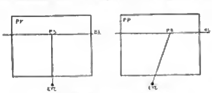


Fig. 3.—Another perspective diagram.

Showing the relative positions in which the horizon line picture plane and station point ought to be regarded

It would be better undoubtedly to construct a special stereoscope with plane prisms allowing of an extensive distant unmagnified field; and, though such an instrument would have to be rather a bulky affair, it would answer the purpose much better for the exhibition of hand-work, and would enable the draughtsman to make his drawings on a less diminutive scale.

Another way is to draw large and reduce by photography to stereoscopic dimensions. With intricate diagrams this is much the best way, and very beautiful results can be produced.

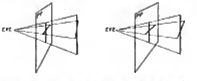


Fig. 4.—Diagram showing how the image of an object is formed on the picture plane by lines drawn from all points of the object to the eye.

The red-and-green-spectacle method of stereoscopic representation is another way out of the difficulty. The two drawings, which may then be of any size, are drawn (almost superposed), the one in green ink, the other in red. Two gelatine films, stained respectively with the same red and green inks, are used for the spectacles, and the figure is seen like a solid wire model in front of the paper. The process, however, is imperfect. With the red gelatine complete extinction of the red lines is easily obtained, but the green lines always show faintly through the green film, unless the dye is so dense as to obscure vision, or unless the color-screen is a liquid one, which is obviously inconvenient, though extremely perfect in its effects.

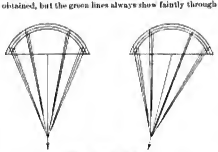


Fig. 5.—The rainbow.

A line is shown, which, if produced, would pass through the spectator to the sun. It will be seen in the stereoscope how the refracted rays form an angle with this line on all sides. The original of this diagram is in colors, making it all the more instructive.

The actual method for drawing for the stereoscope is very simple, extreme accuracy being the main essential of success.

Bearing in mind the prescribed limitations of size and angle of vision to which reference has already been made, the object is first drawn in perspective in the ordinary way. Take, as a simple illustration, a cube. The perspective representation is drawn as on the left in Fig. 1. Pencil lines are drawn horizontally from each determining point of the figure, as shown by the dotted lines in the illustration. These are guides for the position of the corresponding points in the right-hand figure. By this means no measuring point is required for the second drawing, as it is obvious that all these corresponding points must lie in a horizontal line with those of the first figure. The right-hand drawing is placed two and a half inches to the right on the picture-plane, the point of sight being moved an additional half-inch, that is, three inches to the right of the original point of sight.

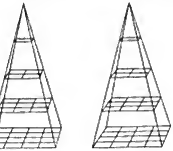


Fig. 6.—The law of inverse squares.

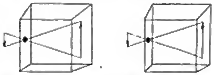


Fig. 7.—The pinhole camera, illustrating the formation of the inverted image.

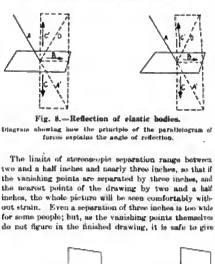


Fig. 8.—Reflection of elastic bodies.

Diagram showing how the principle of the parallelogram of forces explains the angle of reflection.

The limits of stereoscopic separation range between two and a half inches and nearly three inches, so that if the vanishing points are separated by three inches, and the nearest points of the drawing by two and a half inches, the whole picture will be seen comfortably without strain. Even a separation of three inches is too wide for some people; but, as the vanishing points themselves do not figure in the finished drawing, it is safe to give them that amount of separation; for probably no part of the actual drawings will be more than about two and three-quarter inches apart.

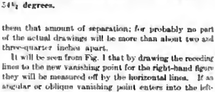


Fig. 9.—Polarized ray reflected from a horizontal plate, but unreflected from a vertical plate when incident upon it at the same angle with the normal, viz., 54½ degrees.

It will be seen from Fig. 1 that by drawing the receding lines to the new vanishing point for the right-hand figure they will be measured off by the horizontal lines. If an angular or oblique vanishing point enters into the left-hand drawing, it must similarly be moved on three inches for the right-hand drawing.

Accuracy is best insured by pricking the paper with a fine needle at each determining point that is established, and then drawing to these needle-pricks.

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[*] From Knowledge.

Having completed the drawing in pencil, test it, without removing the construction lines, by examination in the stereoscope. If it is true, the whole may then be carefully ruled in with ink. If the stereoscope reveals faults, the lines should be carefully revised and corrected in pencil until they correspond in the two drawings.

It is a good plan, instead of inking over the original, to mount it, when all the determining points are quite accurately placed, over a piece of blank paper on a drawing board, and with a fine needle, mounted in a handle, prick through all the holes, so as to stencil the whole key to the diagram on the lower sheet. Two sheets or more at a time may thus be stenciled, taking great care that the needle-holes are made absolutely vertically. Join up the points on the stencils in ink with a ruling pen, and each will give a complete stereogram.

If the work of preparing the drawings is considered too tedious and troublesome, the services of a professional draughtsman may be engaged; and, by providing him with plan and elevation, and such instructions as are given above, he will produce results much more perfect than those to which the unpractised amateur can attain without repeated trials and failures. Figs. 5-8 accompanying this article were drawn in this way and are good examples of professional accuracy.

Figs. 2-4 are specimens of an instructive series illustrating principles of perspective.

Fig. 5 represents the principle of the rainbow, and makes it clear how the refracted rays from all parts of any color band all form the same angle with a line from the sun to the spectator; a fact which is often puzzling to students.

Figs. 6 and 7 represent respectively the law of inverse squares and the principle of the pinhole camera.

Fig. 8 is a diagram to illustrate the laws of reflection of elastic bodies.

Figs. 9 and 10 are from a series of polarization diagrams, and show special cases in which the stereoscopic method takes the place of models in a satisfactory manner.

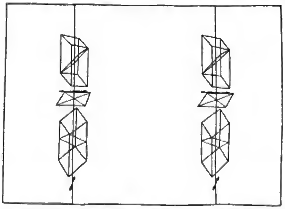

Fig. 10.—Diagram showing the change of plane effected in a ray in passing through a nicol prism; secondly, through a film of selenite; and, lastly, through a second nicol.

An Historical Sketch of the Gas Engine

Tracing the Origin and Development of Different Types

By John Hays Hammond, Jr.

TO-DAY the field of the internal combustion engine is being viewed in its prospect; in a retrospect of the evolution of the gas engine we can pay a slight tribute to those pioneers whose efforts have benefited humanity at large.

From the year 1678 A. D. when many unsuccessful attempts were made to utilize the expansive energy of gunpowder until the present day, the progress toward the perfection of the internal combustion engine has been a uniform one. The main factor in the adoption of any type of prime mover has always been the question of economy, and in this respect the internal combustion engine ranks supreme, both in thermal efficiency, general simplicity and compactness of structure.

The pioneers in the field of gas engineering were numerous, each to a certain extent adding to the general knowledge of its phenomena, but there are comparatively few to whom may be credited any radical changes. Among the illustrious names connected with the experimental work which has brought the gas engine to its present high state of perfection, are those of Beau de Rochas, Million, Daimler, and Otto, all contributors of invaluable information to the art.

It is, however, to De Rochas, a French engineer, whose knowledge in the theoretical conditions of the gas engine far exceed his time, that we owe the theory upon which our modern units are built and operated. He was the first to realize the inestimable advantages of high revolutionary speeds, high compression, and the consequent high thermal efficiency which is now generally recognized as the main factor of economy. It is rather curious that though cognizant of these facts, Beau de Rochas never cared to practically demonstrate his views; it can, however, be accounted for, for De Rochas was much of the theorist and but little of the practical engineer, and he left it for others to make concrete his ideas. It was not until fifteen years after enumerating his principles (1877) that practice adopted his revolutionary ideas. Besides predicting the advent of the four-cycle motor, De Rochas advocated combustion by compression, which principle we find involved in the modern Diesel engine.

Occupying the same position in practical inventions that De Rochas occupied in the theoretical, ranks Otto. This German engineer was the inventor of the first practical four-cycle engine. Although invented in 1876, the four-stroke engine is still in the market, outnumbering by a vast majority all other existing types of motors.

In opposition to the four-cycle or Otto cycle engines, we find the two or two-stroke motor to be theoretically possessed of many valuable qualities. Though considered with respect to their relative practical merits, it is hardly necessary to mention the fact that the Otto cycle is for medium power units much more efficient, for its preponderance over two-cycle motors on the market testifies to this. To the layman, however, it would seem that the two-cycle engine would be far the most preferable of the two types, for with twice the number of explosions and the same weight combined with greater simplicity, we should expect far more efficient service. In matter of fact, however, we find that instead of giving twice the horse-power for a given bulk and weight of the four-cycle engine, the two-cycle engine when run at any speed over 800 revolutions per minute ceases to operate with reliability, for its necessary functions of inhaust and exhaust do not take place. Consequently, we find two-cycle units operating under conditions where the factor of speed is not a requisite for its efficient service. Special modifications as found in the Diesel type, however, allow the two-cycle principle to be very efficient in high power units.

At the present time there are two recognized classes of internal combustion engines, one the working or low speed engine, the other the high speed motor. As the working engine far antedates the modern motor, and in fact forms the basis from which the high speed motor was finally evolved, we may first consider its invention and gradual development.

The history of the working gas engine deals principally with the experimenting of English engineers, for they did more to further its progression than did the engineers of any other nationality. Due to the small quantity of natural fuel in the British Isles, the English engineers realized the great possibilities in the adoption of gas as a fuel, and concentrated their energies in the production of a serviceable, economical, reciprocating engine.

As far back as 1825, we find attempts to use the presence of a vacuum by the explosion of gas, as a medium to actuate a suitable mechanism.

In 1833 Wright obtained patents on an engine of the double acting type, which was operated by the alternate explosion of gas on both sides of a piston. This engine, though comparatively antiquated, shows many of the modern principles; the most important one being the use of the non-compression system which we now find in some units.

William Barnett evolved the system of "naked flame" ignition in 1838, which he incorporated in the construction of his engine. This form of ignition has been extensively used for years in stationary power units, and has fairly recently been dispensed with for the less complex and more convenient types of ignition by electricity. In another respect also, we find Barnett's engine of interest, as it is one of the first gas engines which embodies the principles of high compression with which we are now so familiar. In mechanical structure, we also find this engine of especial interest, as it is about the first scavenging gas engine built. By the term "scavenging," we include all engines of the two-cycle type to which is affixed some suitable pumping or blowing device which is designed to render more positive the performance of its various functions. In the smaller units we may mention that it has not been found a commercial practicability to construct scavenging motors, but in high powered stationary engines of low revolutionary speeds, we find many cases where it has been adapted with marked success.

We find an instance of the first use of hot tube ignition in the year 1855, when A. V. Newton invented this system, which, until recently, was much used in foreign automobile practice.

Although up to this time much experimenting has been done, there was no instance where a practical commercial machine was ever built, and it is Lenoir who first initiated the gas engine in the commercial field. In 1860 Lenoir put on the market a horizontal gas engine, which was, in exact copy, a reciprocating, simple acting, steam engine, except for detailed changes in the admission and exhaust valves. An evidence of the commercial success of this engine is evinced by the fact that in 1865 over three hundred of his engines were operating throughout France. It is curious that this should be the case, for with a fuel consumption averaging from 2.5 to 3 cubic meters of gas per horse-power it could not compete with the poorest of our present units. However, for that time Lenoir's engine was considered highly economical.

During this period of comparative enlightenment among gas engineers, it is remarkable how erroneous were their ideas concerning the phenomena of the combustion of gases. Although Bunsen and Hirn were contemporaneous with this time, and fully understood and demonstrated the action of combustion in gases, yet we find cases where stratification of the gases in a cylinder was attempted by the injection of steam. The reason we learn for this experiment was the fallacious idea that by lengthening the duration of explosion a consequent gain in economy would be effected. This theory is in direct opposition to the now established fact that the greater number of heat units is derived during the actual expansion of the gases.

In 1876 Otto established his revolutionary change in the cycle of the gas engine. As previously mentioned, this cycle had already been considered from a theoretical standpoint by De Rochas. The economy of this new type was marked, for in the earliest four-cycle motors a fuel consumption was recorded of only 24-30 cubic feet per horse-power-hour. With this apparent advantage of economy, coupled with great reliability, Otto's engine soon ousted all other competitors from the field, and rapidly became the universally adopted type.

Some idea of the popularity of the Otto engine may be gleaned from the fact that since its manufacturing company was incorporated (1880), the firm has produced 25,000 separate units representing over 100,000 horse-power (to 1905).

Having considered, in outline, the growth of the low speed, internal combustion engine, we may now turn to the more recent evolution of the high speed motor.

It is the French and Germans whose mechanical genius has done much to perfect the modern motor, which has proven so highly successful in the propulsion of many types of vehicles. And it is wholly to Gottlieb Daimler that the honor of its invention belongs.

This German engineer has well earned the appellation of "Father of the Automobile" for he was the first pioneer to successfully solve the problem of the self propulsion of vehicles. In 1886, Daimler, who was the manager of the "Otto Engine Works," at Deutz, Germany, built a simple form of air-cooled motor which he at first experimented with on a bicycle. Three years later he developed, from this experiment, a motor which proved so efficient that Messrs. Panhard & Levassor of Paris bought the necessary rights to it, and laid the foundation of a corporation which now leads the world in this particular phase of motor construction.

With the tremendous impetus thus given to the industry by Daimler a rapid development followed. Peugeot Freres and many other companies were organized, and gas engine manufacture soon took place on a far larger scale than heretofore.

To trace the metamorphosis of the high speed motor, it will be necessary to consider the history of the automobile, for it is in the usage of vehicle propulsion that this motor has been found most adaptable.

One of the earliest severe tests that is recorded in the history of automobiling, to ascertain the existing deficiencies in automobile engines, was the race which took place in France in the latter part of 1894. The competing machines were two 3.5 horse-power Panhard cars, which were respectively driven by Messrs. Panhard and Peugeot, both ardent enthusiasts in the sport. The following year a second race ensued in which M. Levassor, driving a Panhard, covered the distance of 730 miles at the then remarkable average rate of 15 miles an hour. But six years from that date the same course was covered at the average speed of 50 miles per hour, which demonstrated forcibly the phenomenal strides the industry had taken.

In the passing of the Locomotive Act in England, during the year of 1896, a great step was taken in the promotion of automobiling as a sport. Previous to this time, the public highways throughout the Island had been closed to all self-propelled vehicles, or in legal phraseology, "light locomotives," so that automobile manufacture was practically non-existent. Following the acceptation of this bill in Parliament, there came a number of foreign built motor cars into England, which soon became so popular that in 1897 the Automobile Club of Great Britain and Ireland was formed.

Meanwhile, in America, the gas motor for vehicles had been developing on somewhat different lines.

In 1878 is recorded the first instance of experimenting in the application of the gas engine for motive power. In this year a Mr. Fawcett of Pittsburgh built an omnibus which was propelled by a Brayton motor. Brayton, though successful in his theoretical experimentation, never succeeded in producing a machine of any practical serviceability, and Fawcett's attempt was relegated to a long list of similar failures.

Following Fawcett's enterprise came C. E. Duryea's construction of a gasoline runabout, which was not completed until 1892. This vehicle was found to be very underpowered, but in 1894 the Duryea brothers adopted a four-cycle type of motor, which proved so efficient that a year later it was entered in the Chicago *Times-Herald* race, where its performance was exceptionally good. Stimulated by this success, in 1896 Duryea organized a company, which built the first thirteen automobiles manufactured in the United States.

Many other men were at the same time endeavoring to overcome the various constructional, and difficulties of design which the manufacture of the automobile engine involved. Mr. Elwood Haynes started his experimenting as early as 1893, but it was not until 1898 that the Haynes Apperson Company was incorporated.

Alexander Winton was also one of the early believers in the ultimate popularity of the gas engine, and in 1898 he constructed his first automobile for the market.

The names of Mr. R. E. Olds, Mr. H. Ford, and numerous others are also intimately coupled with the early growth of the art.

Though much work was done by our American engineers to perfect the automobile engine, it was on altogether different lines from foreign practice. It was generally believed among our pioneer engineers that the horizontal engine was the better type for the motive power in vehicles, but long years of constant experimenting and actual service has proven that the foreign idea of the vertical engine is by far the most preferable generally for automobile usage.

Concrete figures can illustrate more vividly than words the stupendous growth of a but lately infantile industry. The manufacture of automobiles in the United States in 1895 produced as a sum total but fifty machines, a production amounting to about $75,000. In 1913 the value of commercial and pleasure vehicles produced in this country conservatively figures over $750,000,000, and many consider the business as still in the development stage.

Ideal Form for Fast Airships

Researches made upon the shapes of fish which travel at fast or slow speeds in the water led two French scientists to consider that the usual shapes of airships have no proper basis for their design, and that for a high-speed airship the ideal shape should have somewhat the form of a shark. Moreover, to sail properly in the air, the balloon should be neither all-rigid nor all-flexible, but should have a combination of the two, that is, a rigid fore end and a flexible rear part.

Airships now in use can be placed in two classes; first, the Zeppelin type, which is made up of a middle cylinder with two conical end caps; and second, the French or flexible type having an elongated ovoid form, with the large end in front. The German airship has a shape which appears to correspond to no idea of adaptation, and its conception is the result of a special idea formed by the designer. On the contrary, the ovoid shape copies that of numerous fish. The two Paris scientists, Profs. Magnan and La Riboisière, now show that this shape with large end in front is the worst form of fish, and, in fact, the slow-speed fish all have the large diameter of the body near the front. Their body is likened to an ovoid made up of a cone having a spherical cap in front.

Observations upon fish make it clear that in the shapes of body where the large diameter lies nearer the rear, this characterizes faster speed fish, and speed follows this displacement toward the rear. Thus the very rapid fish, such as the shark, trout and the like, have the large part lying near the middle of the body and not in front. Again, they notice that rapid fish have not the same general shape of body as the others. They define the body of the rapid fish as made up of a rear cone pointing backward for the end of the fish, a front spherical cap for the head, and a middle or joining part, which is a truncated cone with the large base to the rear; that is, front rounded end, conical part expanding toward the middle, then a diminishing conical part toward the rear. Fish are adapted to the aqueous medium, and their shape results from pressures produced by the water on the body. It is the resistance which the water opposes to their progress that, so to speak, "models" the body of the fish. This is evidenced by the fact that mammifers, such as the whale, who left terrestrial for aquatic life, also have their bodies changed in shape, and in fact formed, as we have seen, so as to resemble the fish in shape. Since the form of the fish is the result of pressures due to the resistance of the water on a certain plastic body which moves at a given speed, we can affirm that the form of any given specimen of fish is that which corresponds to a shape having least resistance.

Rapid fish like the shark have, therefore, a special form, with large diameter near the middle of the body, because this form corresponds to that in which the effects of modeling by the water cease to manifest themselves. Basing their theories on the above conclusions, obtained from actual observation of fish, the authors design a form of balloon body to copy the rapid fish, such as the shark. One interesting point is that the fore end is rigid, and this part is made as a kind of penetrating cone, the rest of the balloon being flexible. This is not only designed after natural conditions, but follows from experiments in which they observed the effect of a bag filled with a thick liquid and placed in the water. It cannot move rapidly through the water unless it has a rigid fore-end, either conic or spherical.

The nacelle of the airship is placed underneath and as close up against the body of the balloon as possible, so as to lessen the resistance to the forward movement and to keep the whole airship close to the ideal shape. At the back of the balloon body is a pair of rudders arranged somewhat like a fish's tail. The dimensions of the proposed airship are: Volume, 290,000 cubic feet; length, 220 feet; maximum diameter, 52 feet; distance of point of maximum from the front end, 120 feet. Width at the maximum is somewhat smaller than the height, or 46 feet, so that the section is not exactly circular, this idea being also copied from the fish. Length of the rigid front cone, 40 feet.

The Spectrum Extended in Extreme Ultra-violet

The researches of Schumann enabled him to extend the spectrum to about $\lambda 1250$, and subsequently Mr. T. Lyman continued it to $\lambda 1030$ by the use of a concave grating. Now Mr. Lyman has succeeded in photographing the spectrum of hydrogen to $\lambda 905$. It is characteristic of the region investigated by Schumann between $\lambda 1850$ and $\lambda 1250$ that, while hydrogen yields a rich secondary spectrum, with the possible exception of one line no radiation has been discovered belonging to the primary spectrum. On the other hand, in the new region between the limit set by fluorite and $\lambda 905$, a disruptive discharge in hydrogen produces a primary spectrum of great interest made up of perhaps a dozen lines. These lines are always accompanied in pure hydrogen by members of the secondary spectrum, but they may be obtained alone if helium containing a trace of hydrogen is employed. Results obtained from vacuum tubes when a strong disruptive discharge is used must always be interpreted with caution, since the material torn from the tube itself sometimes furnishes impurities. In the present case, it will be some time before the effect of such impurities can be estimated. However, it may be stated with some degree of certainty that the diffuse series predicted in this region by Ritz has been discovered. The first member at $\lambda 1216$ is found to be greatly intensified by the disruptive discharge, and the next line at $\lambda 1026$ appears also, though very faintly. This diffuse series bears a simple relation to Balmer's formula. Following the same kind of argument, a sharp series corresponding to the Pickering series might be expected. The new region appears to yield two lines belonging to such a relation at the positions demanded by calculation.

Drying Grain by Electricity

At some mills grain is being dried by electricity. The heating devices are installed in the casing inclosing the spiral screw that conveys the grain from the storage bins to the stones, and the grain is thus thoroughly dried immediately before it is ground. This drying is reported to make the grinding easier and to also insure a better and more uniform quality of the product of the mill.

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The garden city of the employees at the works of Messrs. Lever Brothers, Port Sunlight, England.

Entrance to the village of old pensioners at the Krupp Works, Essen, Germany.

Workers' cottages at the Krupp Works, Essen, Germany.

EFFORTS FOR THE WELFARE OF WORKMEN IN EUROPEAN MANUFACTURING ENTERPRISES.—[See page 360.]

Electric Furnaces for Heating Steel—II*

Facts and Figures Relating to New and Valuable Methods

By Alcan Hirsch

Concluded from Scientific American Supplement No. 2030, Page 339, November 28, 1914

The temperature and the production of steel from an electric furnace are mutually dependent. The heat liberated in the resistor, if not taken up by the metal, will occasion a rise in temperature of the furnace. The larger the electrical capacity per unit of hearth, the greater the effect on the temperature by alteration in the production. It is for this reason that productions over 50 pounds per hour per square foot of hearth should be avoided. With moderate capacities of 4 or 5 kilowatts per square foot of hearth area (equivalent to a production of 30 to 35 pounds of steel per hour to 1,700 deg. Fahr.) variations in production have but very little effect on the temperature. The heat capacity of the resistor lining and brickwork in furnaces of this size is amply able to compensate for changes in production, so that the temperature remains practically the same. A furnace designed for a normal running load of 4 kilowatts per square foot of hearth (with 1½ volts per inch length of the resistor) will prove very satisfactory. The uniformity of temperature on the hearth in furnaces employing the T-shaped resistors shown in Fig. 3 is quite remarkable, but even with the U-shaped or serpentine resistor a temperature variation of less than 10 deg. Fahr., in any point of the hearth from the desired temperature, is to be expected.

Enameling furnaces fall quite in the same category with the heat-treating furnaces. Although they are larger in size they are not correspondingly large in electrical capacity. For enameling furnaces resistors should be placed on the sides, but about three-quarters of the kilowatt input should be liberated in the base. Resistors when placed along the sides of a muffle of an enameling furnace should be small, 10 to 20 square inches in section and should consist entirely of graphite. The lining of such a resistor is usually designed so as to form a part of the interior wall of the muffle.

ELECTRIC FURNACES FOR TEMPERATURES ABOVE 1,800 DEG. FAHR.

With respect to the class of furnaces operating over 1,800 deg. Fahr. the writer knows of no example in industrial work, except on a small scale, which has proven satisfactory. A number have been constructed and tried for various lengths of time, but a durable furnace, certain of operation, is yet to be produced. Most of the experiments which have been conducted have employed furnaces with a single resistor about half graphite and half charcoal, as mentioned above. These resistors have been made about a foot and a half wide and placed in a trough of a mixture of refractories, the basis of which is firesand. The metal to be heated was placed directly above the resistor, but not touching it. The metal was steel bars for forging and heated to about 2,400 deg. Fahr. In order to effect a production similar to that of an oil-fired forge furnace of the same size, the temperature of the resistor had to be above 2,900 deg. Fahr. For this temperature it seems impossible to construct a furnace which will have a very long life. In the course of a few weeks the lining or the bricks will have fluxed to some degree and rebuilding will be found necessary. A lining of substantially pure silicon carbide brick might stand up under these conditions, but it is questionable if a refractory any poorer than this would be satisfactory. The electrodes, too, are difficult to hold in place without costly supports which might have to be water-cooled. These furnaces have been used for heating metals for forging and have shown in some instances good economy. A current consumption of 370 kilowatt hours per 2,240 pounds of metal on a 100 kilowatt furnace was noted. In general, the type of construction on these furnaces was similar to that shown in Fig. 2, except that the U-shaped resistor was substituted by a single straight one running from one end of the hearth to the other.

For work at forging temperatures a furnace employing a graphite resistor does not seem capable of becoming a commercial reality unless a very unique lining can be developed.

ELECTRIC FORGE FURNACE OF THE ARC TYPE.

The writer has given considerable thought to this important field of electric furnaces for forging and has developed a furnace which appears to eliminate most of the difficulties encountered. This furnace is as yet only in the experimental stage, although it appears to offer attractive commercial possibilities. It is of the arc type and thus immediately many of the difficulties inherent to the resistor furnaces disappear. As there is no resistor there is, of course, no resistor lining. The metal is placed on the hearth and is heated directly by the arcs, the bases of which play a few inches above the metal to be heated, thus obtaining a high thermal efficiency. The arcs are deflected by means of an auxiliary electrode which spreads the flame of the arcs so as to distribute the heat comparatively evenly and also serves to protect the roof of the furnace. The roof, if built of silicon carbide brick, will have a long life. As the electrical equipment is placed above the hearth it is easily accessible and may be removed by a crane so that a new top can be placed on the furnace in a very few minutes. As arcs of a few kilowatts are difficult to operate, it would probably be necessary to build a furnace capable of a very substantial production. The writer hopes that definite commercial data regarding this furnace can be secured very shortly.

DESIGN OF FURNACE FROM STRUCTURAL STANDPOINT.

Fig. 3 shows a heat-treating furnace of 125 kilowatt capacity under the normal running load. It has a maximum capacity of 175 kilowatts. The hearth is 5 feet wide and 9 feet long inside.

A very satisfactory furnace wall has been found to consist of two bricks laid so as to make 9 inches and with 3 inches of kieselguhr. The kieselguhr may be placed between the bricks forming a vertical channel, or may be placed outside the bricks, in which case, sheet metal is employed for the outside of the furnace to hold the kieselguhr in place. Asbestos mill board may be used in place of sheet metal. This does not lower the heat losses, and, of course, the mill board is not quite so durable as the sheet metal. Furnaces may be well insulated on the top and sides of the hearth, but care must be observed not to insulate the base too well. It must be recognized that in electric furnaces the heat is evolved within the brickwork and is, consequently somewhat different from the fuel-fired furnaces. Hence, the furnace should be set clear of the floor with only about 15 inches of brick allowed up to the lining on the base of the resistor. Ten or 12 inches are quite sufficient for this dimension for furnaces working above 1,700 deg. Fahr. The brick employed should be good fire brick. Silica brick serve excellently for this purpose. These brick run about 95 per cent silica and contain a little lime. Good masonry work and particularly well constructed arches will be much the cheapest in the long run. Throughout the furnace construction the same principles as are observed in oil furnace design are, of course, applied to electric furnace construction.

It is most important to select the proper refractory for the lining of the resistor. The lining is usually in the shape of a trough, the resistor being placed in it. The lining material must have a high melting point; it must not have a high vapor pressure at its operating temperature; it must not react chemically with the hot resistor on one side or the brick on the other; and it must not become soft or "mushy" at the operating temperature. Its electrical conductivity at the operating temperature must be considerably less than that of the resistor and it must be relatively cheap.

The operating temperature of the lining is rather high, normally a few hundred degrees higher than the hearth temperature, but for various reasons the maximum temperature obtained in a lining may be a thousand or more degrees higher than the normal operating temperature. The reason for obtaining these high temperatures in the lining may be due to neglectful operation or an attempt to get an extraordinarily large production at a particular time. It is, therefore, necessary to employ a lining having a high factor of safety as regards the temperature. It is exceedingly difficult to find a material which meets these requirements at a temperature of 2,000 deg. Cent. (3,632 deg. Fahr.). It must be remembered that although refractories of high melting point are available, the addition of the necessary binder, even though in small amount, may lower the fusing point of the lining very materially. Either of the following substances[2] having high melting points might be employed as the principal constituent of a refractory for use in a furnace operating above 2,000 deg. Fahr.

Refractory.	Melting Point.	
	Deg. C.	Deg. F.
Calcium carbide (boils at 2,015 deg. Cent.)	1995	3623
Aluminium oxide	2020	3668
Uranium oxide (U_3O_8)	2176	3946
Uranium carbide	2425	4396
Zirconium oxide	2500	4532
Vanadium carbide	2750	4982

In addition two other substances should be mentioned. Glucinum oxide has a high melting point, and boron nitride shows no sign of sintering at 3,000 deg. Cent. (5,432 deg. Fahr.).

Magnesium oxide begins to vaporize under atmospheric pressure at 2,000 deg. Cent. (3,650 deg. Fahr.). All metallic oxides are somewhat acted upon by hot carbon, and as the speed of reaction approximately doubles for every 10 deg. Cent. rise in temperature, at electric furnace temperatures this chemical action is often sufficient to deteriorate considerably if not destroy the lining entirely. At about 2,000 deg. Cent. (3,632 deg. Fahr.), magnesia is rapidly attacked by carbon.[3]

The electrical conductivity of lining materials, especially metallic oxides, increases very rapidly with the temperature. Materials which are excellent insulators at room temperatures become fine conductors at electric furnace temperatures and this should be borne in mind in connection with the linings. For example a slab of alundum (fused alumina) had a specific conductivity[4] at 1,600 deg. Cent. (2,912 deg. Fahr.) about 50,000 times as great as at 20 deg. Cent. (68 deg. Fahr.).

In the writer's experience silicon carbide firesand offers advantages over other refractory materials for the linings of furnaces considered in this paper. A mixture of silicon carbide firesand 85 parts, and water glass (38 deg. Baumé) 15 parts, forms a good lining when well baked in the furnace. A slightly better lining can be made by using the above mixture for the outside of the trough and pure silicon carbide with the water glass in the same proportions for the inside next to the resistor. The lining is put in place with the assistance of wooden forms, and allowed to dry; when the furnace is started it becomes well baked. At operating temperatures such a lining is a much poorer conductor than graphite, and there is practically no chemical action between it and either the carbon or silica brick with which it is in contact. Silicon carbide begins to decompose at about 2,300 deg. Cent. (4,172 deg. Fahr.) into carbon and silicon, which vaporizes, but it has given excellent service over a considerable period of time. A silicon carbide lining, properly built in a heat-treating furnace designed to give a hearth temperature of 1,850 deg. Fahr., should not need renewal more often than once in six months and frequently such linings last much longer. It will be seen, however, that linings are relatively expensive items in furnace construction so that the firesand is probably the most economical, particularly if 1,700 deg. Fahr. is the maximum hearth temperature desired.

The writer begs to suggest that the question of linings for this type of furnace offers an attractive field for research and he sincerely hopes that scientific work along these lines will be made by investigators.

Electrodes are placed in the furnace imbedded in a mixture consisting of silicon carbide 90 parts, tar (melting point 100 deg. Fahr.) 10 parts. They project from the furnace wall about 6 inches into a box without a top and made of asbestos mill board with a framework of small angles attached to the furnace. The leads are run into the box from the top and are clamped to the electrodes. The box is then filled with kieselguhr. The electrodes may be of either graphite or carbon, preferably the former. The size of the electrodes may be calculated by the well known methods,[5] and either the square or round form may be used.

The switchboard has a main switch, and a radial switch with a number of points, if a transformer is used. The switching may be accomplished on the high tension or the low tension side of the transformer, as is desired. If regulation is effected by altering the resistance with a furnace such as is shown in Fig. 3, knife switches alone are used, as no transformer is employed. The resistors are thrown in or cut out by single bladed knife switches, as desired. An ammeter is employed in all cases unless the primary tension is too high to warrant satisfactory operation of same. The ammeter is, of course, always placed on the primary side of the transformer. If an ammeter cannot be used a wattmeter may be employed, or it may be used if an ammeter is not desired by the operator.

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* Author's abstract of report on research carried out under a Carnegie Fellowship granted by the Iron and Steel Institute of Great Britain. The complete report of this work was presented at the Annual Meeting of the Institute, May 7th, 1914. This abstract is reprinted from the *Journal of Industrial and Engineering Chemistry.*

[2] "Fusion and Volatilisation of Highly Refractory Materials," Ruff and Goecke, *Z. angew. Chem.*, 24 (1911), 1459.

[3] O. P. Watts, "Action of Carbon on Magnesia," *Trans. Amer. Electrochem. Soc.*, 11 (1907), 279.

[4] E. F. Northrup, *Metal. Chem. Eng.*, 12 (1914), 125.

[5] The writer believes the best method for determining the proper cross-section of electrodes is contained in an article by Carl Hering, "Empirical Laws of Furnace Electrodes," *Trans. Amer. Electrochem. Soc.*, 17 (1910). Table VI in this paper may be employed very satisfactorily for the calculations.

Wiring should be quite carefully done and with sturdy construction. The chief precaution to observe is to insulate all conductors of current and have such insulation located so that the furnace heat will not injure it. In most cases it is preferable to run the conductors down from the electrodes along or beneath the floor to the switchboard. The switchboard, of course, must be accessible to the operator of the furnace, and is preferably placed by the side of the furnace near the end having the door.

Operation of an electric furnace of the graphite resistor type is found to be very simple. A new furnace is started up slowly, the voltage equivalent to one volt per inch length of the resistor being applied for about 12 hours. At the end of this time it may be brought up to temperature by gradually raising the voltage per unit length of the resistor. The metal is passed through the furnaces, the operation being quite the same as in the fuel-fired furnace, and with a very little experience the proper load for each particular job may be readily ascertained. If a change in the production of steel occurs in the furnace, or a change in temperature is desired, it is advisable to raise or lower the kilowatt input, as the case may be, about 15 or 20 minutes before the change occurs. Otherwise, failure to get the production on the one hand, or failure to get the temperature on the other, may be the result.

When the furnace is to be shut down the current may be turned off 15 or 20 minutes before the last piece of metal is removed. The furnace is then closed and as it is quite hot, will take but a short while to heat up after the usual over-night shut down of 14 hours. The time to heat up after such a period is from 20 to 30 minutes. To heat the furnace up from cold requires about one hour.

As previously stated the resistor burns away partially and must be replenished. This should be done at intervals of about 70 hours of operation on furnaces operating from 1,700 deg. Fahr. to 1,800 deg. Fahr., but furnaces running at lower temperatures will last for longer intervals without replenishing. At 1,700 deg. Fahr. hearth temperature the consumption of graphite is approximately 0.01 pound per kilowatt hour. The graphite may be charged through small port-holes, located in the sides of the furnaces, by means of long handled scoops. It is then raked down with a small rake adapted to the particular resistor.[1] In some instances the resistor runs uncovered or partly uncovered along the sides of the hearth in the interior of the muffle. In this case the graphite is shoveled in through the furnace door. The proper amount of graphite to be used will be found readily by a few trials, noting the position of the switch before and after charging for the same load.

As the regulation is accomplished by simply throwing the switch, the furnace may be regulated by the workmen. The wiring, of course, must be arranged so that it is impossible to short-circuit the line by means of the switches. The workmen, however, must be instructed not to run the furnace on a voltage equivalent to 1.8 or 2 volts per inch length unless the production really warrants it. Otherwise, overheating may sometimes occur between charges while the furnace is empty. To provide against overheating in this manner, fuses should be carefully selected of low amperage, which is determined by the maximum rate at which the work should be done. This precaution is to be observed particularly on furnaces where productions are varying widely from day to day. For temperatures over 1,800 deg. Fahr. it might be advisable to equip the furnace with a pyrometer constructed so as to operate a circuit breaker when the maximum desired temperature is reached.

EFFICIENCY.

Although the furnace has been designed with the idea of supplying enough current to heat the metal and to make up the losses of radiation, etc., the superintendent of the heat-treating department is very likely to consider the furnace from a standpoint of efficiency. This may be expressed in per cent of kilowatt hours per unit of production. Table II shows the relation between these two methods of expressing efficiency.

In general, the larger the production of metal in a particular furnace, the greater the electrical efficiency. Too high production, however, usually means difficulties in control and with very high production there is danger of overheating should there be slackening in the production without a corresponding change in the kilowatt input being made. The aim to make a production at a rate equivalent to 4 or 5 kilowatts per square foot of hearth and also at 65 to 75 per cent efficiency is an excellent one. When the cost of current is rather high, work which necessitates a production at a lower efficiency than 60 per cent should be transferred to a smaller furnace if the shape of the pieces permits. On furnaces under 30 kilowatts capacity these figures do not apply, as the efficiency on such small furnaces is very much less than on the moderate size ones of 50 to 125 kilowatts.

TABLE II—NUMBER OF KILOWATT HOURS REQUIRED TO RAISE ONE TON (2,240 POUNDS) OF STEEL TO VARIOUS TEMPERATURES AT SEVERAL EFFICIENCIES.

Rise in Temperature.		Percentage Efficiency.				
		50	60	70	80	100
		Kilowatt Hours Required.				
Deg. F	Deg. C.					
950	528	89	111	127	148	178
1050	584	103	129	147	172	206
1150	639	118	147	168	196	236
1250	695	134	167	191	223	267
1350	750	150	187	214	249	299
1450	806	164	205	235	274	328
1500	834	171	214	245	286	342
1550	861	178	223	254	297	356
1600	889	188	235	268	313	376
1650	916	197	246	282	328	394
1700	945	207	259	296	345	414
1750	972	217	271	310	362	434
1800	1000	222	278	318	370	445
2350	1306	272	340	388	453	544

INSTALLATION OF FURNACES.

In order to determine the number and size of furnaces for an installation a careful inquiry into the nature and quantity of the production is necessary. The maximum and minimum productions must be met with as high efficiency as possible for the various productions. Frequently a moderately large furnace to operate all the time, accompanied by a smaller one to be operated as needed, is much more economical from a point of view of current consumption in the long run, than one furnace capable of the maximum production. Care must be observed not to make the furnace too large for the sake of being on the safe side. A furnace so large that it takes 10 per cent more current than a smaller one exactly suited to the work, would waste enough current in the course of six months, or a year at the outside, to pay for a complete new installation. Sometimes the labor requirements determine the size of the units. Two men on a single furnace might not be able to accomplish so much on the one furnace as they would if operating two smaller size furnaces. Here the decreased efficiency in two furnaces must be carefully compared with the saving in labor.

SELECTION OF TYPE OF FURNACE.

In the selection of the type of furnace for the particular work, if 10 square feet or more of hearth area are required, a furnace regulated by the resistance method, Fig. 3, is certainly to be preferred. This furnace costs about half as much as the furnace equipped with a transformer and has a much more uniform heat liberation in the hearth. Electric furnaces with resistance regulation including all the electrical equipment, cost about the same for installation as a good oil furnace, and frequently are somewhat cheaper if blowing equipment installation charge for the oil furnace is included. As a rule these furnaces operate on a higher voltage than do the furnaces having a special transformer so that a saving in copper for the conductors is sometimes effected. They can be designed to operate on the standard voltages, 220 volts being very satisfactory, and, of course, can operate on either direct or alternating current. The larger furnaces can be built to operate on two- or three-phase lines, but those taking 100 kilowatts or less are best constructed for single-phase or direct current. For the small furnaces, such as the one shown in Fig. 4, a regulation by means of voltage is best with a transformer having a secondary with several taps, as mentioned above, either with or without the resistance regulation in conjunction with it.

USE OF ELECTRIC FURNACE FOR HEAT TREATMENT DEPENDENT ON THE COST OF CURRENT.

The extent of the use of the electric furnace for heat treating depends quite largely on the cost of current. Fortunately, in this connection, the resistance furnaces have a remarkably steady load. The starting load is somewhat less than the running load. In a large number of cases the mean running load is found to be between 80 and 90 per cent of the maximum demand. Under these circumstances, particularly with operation extended into or through the night, current can usually be furnished for a low figure. The price of one cent per kilowatt hour is frequently sufficient to warrant the employment of the electric furnace in place of oil on the ground of cheaper cost of operation alone. Current for three-quarters of a cent per kilowatt hour frequently proves as cheap as any method of firing when all factors are considered. Among these factors, most of which have been duly considered, might be mentioned the lower labor charge which is usually effected by the introduction of the electric furnace. The furnace is conducive to high production on account of the fact that it is not so uncomfortable for the workmen as the fuel-fired furnaces. Besides the fact that it is relatively cool and the elimination of all smoke and dirt, and the attendant difficulties with the products of combustion, the electric furnace is much more satisfactory from the workmen's standpoint than any heretofore produced.

Musical Woods

Now that America is taking stock perforce of the materials within her own borders which may replace supplies heretofore from Europe, it is worth while noting the characteristics that lend value to certain woods for the purpose of making musical instruments. It is said, for example, that Stradivarius could never have produced his golden-toned violins but for the precious stock of choice and seasoned wood bequeathed to him by Amati.

A late number of *Cosmos* gives some interesting data on this subject. The main quality desired, is, of course, sonority and the wood chiefly utilized is that of the *epicea*, which is often confused with the fir, to which its general aspect is similar.

The *epicea* is found in a wide range of conditions growing both in flat and in mountainous country, especially in central and northern Europe.

"Like all other conifers its wood is composed of a single element, i. e., fibers or aerolated vessels, and its great homogeneity of structure renders it admirable for the production of sounds. Hence it is used for making violins, guitars, mandolins, sounding-boards, etc. Either the sap-wood or the heart can be employed, since there is scarcely any difference between these in the *epicea*, a condition which is very rare in most trees."

A valuable point with those interested in the exploitation of this timber is that trees which have grown on plains, and especially those which have grown in the vicinity of swampy land yield wood which is soft, spongy, and easily altered. Trees which carried on their struggle for existence in a rather severe climate and at a considerable altitude—800 to 1,500 meters—are much more valuable to the instrument maker because their wood has grown slowly and acquired a highly desirable compactness. It is advisable to make use only of timber which has had not less than two or three hundred years of growth, having concentric circles only two or three millimeters apart at most.

In the most valuable instruments maple is used for the "box;" for the cheap ones the tropical wood violet-ebony is employed, while for those of medium price alternate leaves of the two are used. The maple is highly sonorous, the sycamore-maple somewhat less so, as it is less compact and less homogeneous than white maple. It is generally reserved for mandolins, because its rings are very apparent. Its wood is hard, of a yellowish-white tint, sometimes striped with green, it is brilliantly lustrous in radial sections. It is found in the United States, Europe and Canada. Instrument makers lay special value on *epicea* from the Swiss Jura, particularly the Vosges.

"The violet-ebony, which is much used for boxes and necks, is an exotic wood imported from India, Africa, Madagascar, and Brazil. That from Rio de Janeiro is particularly esteemed and is much used for making pianos. It is of a dirty gray color marbled with chocolate at the heart, with very visible pores, and slightly wavy stripes. It is close-grained and possesses an agreeable odor."

A great deal of ebony is also used for making dyes, twisters, strings and nuts. This wood, whose blackness, hardness and denseness are well known qualities, is also of tropic origin, but it is far less used than formerly, because of its vast increase of price in late years.

The quality of solidity, plus a definite degree of suppleness, are the features required for making bows of stringed instruments. Various tropical plants furnish this combination, especially the iron-wood, which grows in Brazil, Paraguay, the Argentine, Guadeloupe Guiana, the Antilles, and the Malayan Archipelago. Pernambuco wood is also valued for this purpose, and grows abundantly in Jamaica and Brazil.

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[1] The upper surface of the resistor should be raked as level as possible, but it is better to have it slightly concave laterally than convex.

Marine Wood Borers

Little Known Crustaceans of Destructive Habits

By Clyde H. Truesdale, Forest Products Laboratory, Madison, Wisconsin

ENORMOUS destruction to timber structures is caused every year by the ravages of marine wood borers. These borers work in salt water throughout the entire length of the seacoast of the United States, but their ravages are particularly severe along the South Atlantic and Gulf coasts.

The damage is caused chiefly by two borers of the mollusk group, the *xylotrya* and *teredo*, and one of the crustacean group, the *liminoria*. The former are commonly referred to as "ship worms," and the latter is sometimes called "gribble." All of these borers are well known to engineers and others who are concerned in the maintenance of wharves and other structures of wood in salt water.

There are, however, two other borers of the crustacean group that are known to be present on our seacoasts. These are called "chelura" and "sphaeroma." Chelura has been reported from only two places on our coast, Woodsholl, Mass., and Provincetown, Mass. Sphaeroma has been reported from several points on the South Atlantic and Gulf coasts—Crescent City, Fla., Milton, Fla., Bay Point, Fla., Palatka, Fla., Tampa, Fla., and Bayou Bonfouca, La.

The appearance of wood attacked by chelura is so similar to the work of liminoria that the identity of the former may have frequently escaped observation, the damage being attributed to liminoria. In *A*, Fig. 1, is shown a specimen of wood attacked by liminoria, and in *B* one attacked by chelura. In each case the size of the bore is about the same. Liminoria galleries usually extend inward, perpendicular to the surface. These are about 1/32 inch to 1/16 inch in diameter, and about ½ inch deep. They lie side by side in countless numbers, the partitions between the galleries being so thin that the wood is easily broken away by wave action, thus exposing new surface to attack. The chelura bore much deeper, and the galleries may run in all directions through the wood. They also attack the wood in great numbers, the walls between the galleries are very thin and the wood is easily broken away by wave action. As shown in the picture, the appearance of wood attacked by liminoria and chelura is very similar. Figs. 3 and 4 show specimens of liminoria and chelura very much enlarged. These borers are no larger than a small grain of rice. Liminoria excavates in wood both for food and shelter, boring being accomplished by very sharp mandibles. Chelura are somewhat similar to shrimp in appearance. They bore with an instrument somewhat resembling a file.

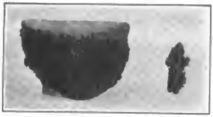


Fig. 1.—Wood attacked by liminoria (left) and chelura (right).

In the first the galleries run in radially and penetrate about ⅜ inch. In the second they run in all directions, and the entire wood structure has been penetrated.

Xylotrya (Fig. 5) is very similar to *teredo*. These borers enter the wood when very small. As they penetrate the wood, however, they grow very rapidly and the galleries increase in size to accommodate the growing body. The galleries average about 3/8 inch in diameter, and 3 inches to 6 inches in length, though under favorable conditions they may reach 1 inch in diameter and 4 or 6 inches in length. The exterior appearance of the surface of wood attacked by ship worms is often very deceptive (*A*, Fig. 2). The entrances to the galleries are

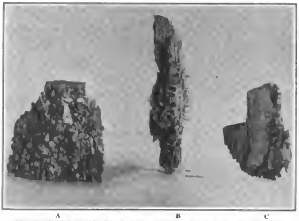


Fig. 2.—Wood attacked by shipworm (A) and sphaeroma (B and C).

Note small entrances to galleries in *A*, and large entrances in *B* and *C*. In *B* is shown attack in palmetto.

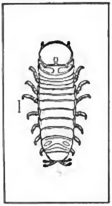


Fig. 3.—Liminoria lignorum.

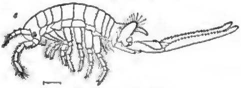


Fig. 4.—Chelura terebrans.

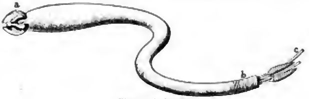


Fig. 5.—Xylotrya.

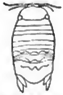


Fig. 6.—Sphaeroma destructor.

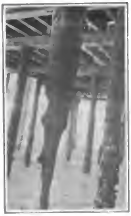


Fig. 7.—Longleaf pine pile destroyed by liminoria at Brunswick, Ga.

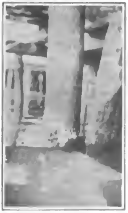


Fig. 8.—Longleaf pine pile destroyed by xylotrya at Pensacola, Fla.

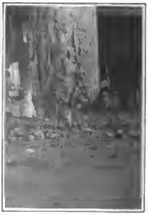


Fig. 9.—Longleaf pine pile destroyed by sphaeroma at Mayport, Fla.

no larger than a pin hole, and the wood may appear to be practically sound until it is cut into, when large and numerous galleries are revealed. This is indicated quite clearly by *A*, Fig. 2. These galleries are always lined by white calcareous material. They intertwine about each other and are usually so numerous that in severely attacked specimens the wood is rendered useless for any purpose. These borers have been known to utterly destroy pine piling in less than thirty days, while the average life of piling on the Gulf coast is less than two years, if the timber is not protected from them.

Sphaeroma has long been known to mankind, and is very common in many parts of the world. It was not until 1898 however that it was known to attack wood. In that year a specimen of wood which was destroyed by an unknown borer was taken from the St. Johns River, near Palatka, Fla., and sent to the Smithsonian Institution. It was identified as a species of *sphaeroma*, and given the name of *sphaeroma destructor*. This borer (Fig. 6) is somewhat similar to the *limnoria*, but very much larger. It is about 1/8 inch to 1/4 inch long, and excavates a round gallery about 1/8 to 3/16 inch in diameter. (The animal is larger than the gallery.) The gallery is of the same diameter throughout, and is usually about ½ inch deep. Unlike the *teredo* gallery, there is no calcareous lining.

The galleries made by the *sphaeroma* are quite similar to those made by the shipworm (Fig. 2, *B* and *C*), where the surface of the latter has been broken away by wave action. Unless one makes a minute examination of the wood, their work would naturally be attributed to the shipworms. This probably accounts for the fact that *sphaeroma destructor* was never identified until 1898, and has been reported from only two or three places since then. *B*, Fig. 2, shows the work of *sphaeroma* in palmetto, which is usually considered to resist the attack of the borers. *C*, Fig. 2, shows attack in a specimen of pine. These pictures show quite clearly the difference in the appearance of wood attacked by *sphaeroma* and shipworms. The most distinguishing feature is the difference in size of the entrance, and the fact that *sphaeroma* rarely bores more than 3/8 or 1/2 inch into the wood.

The damage done by *sphaeroma* has been greatly underestimated. Unlike the other borers described, it works in either fresh or salt water. The St. Johns River at Palatka, Fla., is one hundred miles from the sea, and practically fresh the year around, yet piling was found badly infested and in some cases destroyed. The author has found it working in the St. Johns River at Jacksonville, Fla., and at Mayport, Fla., which is within two miles of the Atlantic Ocean. At the latter place, its ravages were of more consequence than those of the shipworm and *limnoria* combined. It was also found to be very numerous at Brunswick, Ga., Charleston, S. C., and at Tampa, Fla. It has previously been reported in a bayou near Slidell, La., and it seems reasonable that this borer may be present along the entire coast line from New Orleans to Charleston, S. C.

All the borers work from the high tide level to many feet below the surface. The damage is most evident between the high and low tide levels because of the action of the waves in breaking away the wood. Typical illustrations of the work of the various borers are shown in Figs. 7, 8 and 9. Fig. 7 shows a longleaf pine pile destroyed at Brunswick, Ga., by *limnoria*. Fig. 8 was taken at Pensacola, Fla., and shows a pine pile destroyed by *xylotrya*. Fig. 9 is of a pine pile at Mayport, Fla., destroyed by *sphaeroma*. It is evident that the destruction of this pile might easily have been mistaken for that caused by shipworms. No illustration is available of a pile destroyed by *chelura*. At *B*, Fig. 2, is shown a specimen of palmetto from the St. Johns River at Mayport, Fla., attacked by *sphaeroma*. This species is generally considered to be immune from attack by borers.

Exact knowledge of the range and extent of the activity of *chelura* and *sphaeroma* is lacking. It would aid in the advancement of science, therefore, if those readers who have an opportunity to observe the destruction of timber by marine wood borers would report the presence of these two borers, wherever found, to the Forest Products Laboratory, Madison, Wis., sending samples of the borers for proper identification.

Electric Ignition Devices for Gas Engines

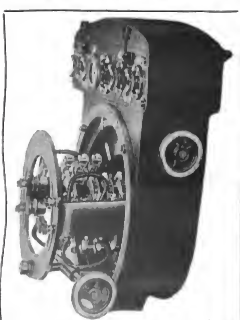
We illustrate an electric device of a recent European design which is now applied very successfully for the ignition of large gas engines. The object of the apparatus, which is quite an elaborate one, though of reliable working, is to produce a quick break at the spark plug inside the engine so as to give the electric arc or spark such as the ignition of the gas requires. At the outside and upon the engine is a device for closing an electric circuit, and when this is done, the spark break is caused to occur under the best conditions so as to cause explosion of the gas. The first part of the apparatus consists of an upright box mounted upon the end of the cam shaft as is seen in the main view, while a second photograph shows some of the details. This device secures the opening and closing of the electric circuits for each of the spark plugs. On the cam shaft is mounted a rotary contact piece, and upon it work the sets of brushes seen in the illustration. Various switching devices are lodged in the top part of the box. Brushes are mounted in a brush-holder somewhat as in a dynamo, and the hand-wheel seen below allows of shifting the brushes so as to regulate the moment of ignition. Besides this, the brushes can be each somewhat altered in position with reference to the others as to make any desired adjustment of the moment of ignition in the rear chamber in relation with the front chamber. Another small wheel at the side of the box regulates the duration of the electric contact, as this is required in engines which run at variable speed; for instance the large gas engines used with blast furnace blowing machines. The second apparatus is the striker which works against the lever of the spark plug. Two of these devices can be seen in the openings of the cylinder casing of the gas engine; and a detail view is also given. At the spark plug inside the engine is a fixed contact against which works a movable electric contact mounted on a rod which passes outside, and is adapted to be worked by a striker, this latter hitting a short lever on the end of the rod so as to cause the break of current at the spark plug. The device here shown consists of a magnet core or armature working on a pivot and carrying a hammer. When the rotary device on the cam shaft closes the electric circuit for the spark plug, the core is attracted by the magnet with a sudden movement, and the hammer strikes the spark plug lever and breaks contact, thus making the arc or spark for the ignition. When the spark ceases the current is broken, and the apparatus loses its magnetism, so that the hammer comes back to zero by a suitable counterweight. Besides being very reliable in operation, this electrically operated break has the advantage that it will work well upon all tensions of direct current between 65 and 220 volts.

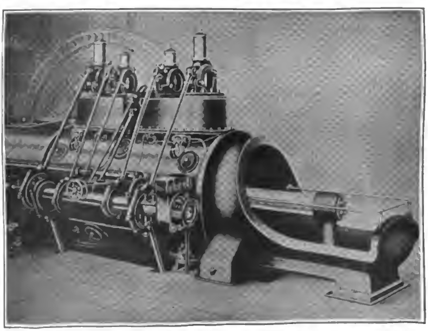
Electrical contact-breaker device.

A Museum of Crime

To Prof. Hans Gross of the University of Gratz, Austria, is due the credit of establishing the first museum of criminology and criminalistic laboratory, where the weapons, tools, and other paraphernalia and materials used by criminals are assembled to assist in the analysis of the workings of criminal minds and a study of methods and systems for dealing with this large and dangerous class of every community. This museum was established in 1895-1896, and since then other establishments of the same character have been organized, following the plans which he successfully formulated.

One of the most important of these is the Society of Criminology and Social Defense in Paris, which has a membership of over two hundred, including many prominent representatives of the law, the police and medical profession; and it was organized to concentrate and centralize the scattered efforts of individuals who were studying this disquieting social problem, and to make the results of their work available for mutual information. The valuable and extensive museum collection of the society was presented to it by M. Pechard, a former Superintendent of Police of Paris, and represents the gatherings of a lifetime.


Rotary contact closer on end of camshaft, showing adjustable contact brushes.


Rear cylinder of a large horizontal gas engine, showing electrical ignition apparatus on end of camshaft, and contact breakers in openings of the cylinder casing.

Acoustics of Auditoriums—I*

An Investigation of the Acoustical Properties of the Auditorium of the University of Illinois

By Prof. F. R. Watson

I. INTRODUCTION.

Much concern has arisen in late years in the minds of architects because of the faulty acoustics that exist in many auditoriums. The prevalence of echoes and reverberations with the consequent difficulty in hearing and understanding on the part of the auditor defeats the purpose of the auditorium and diminishes its value.

The Auditorium at the University of Illinois presents such a case. The building is shaped nearly like a hemisphere, with several large arches and recesses to break up the regularity of its inner surface. The original plans of the architect were curtailed because of insufficient money appropriated for the construction. The interior of the hall, therefore, was built absolutely plain with almost no breaking up of the large, smooth wall surfaces; and, at first, there were no furnishings except the seats and the cocoa matting in the aisles. The acoustical properties proved to be very unsatisfactory. A reverberation or undue prolongation of the sound existed, and in addition, because of the large size of the room and the form and position of the walls, echoes were set up.

If an observer stood on the platform and clapped his hands, a veritable chaos of sound resulted. Echoes were heard from every direction and reverberations continued for a number of seconds before all was still again. Speakers found their utterances thrown back at them, and auditors all over the house experienced difficulty in understanding what was said. On one occasion the University band played a piece which featured a xylophone solo with accompaniment by the other instruments. It so happened that the leader heard the echo more strongly than the direct sound and beat time with it. Players near the xylophone kept time to the direct sound, while those further away followed the echo. The confusion may well be imagined.

Thus it seems that the Auditorium was doomed to be an acoustical horror; that speakers and singer would avoid it, and that auditors would attend entertainments in it only under protest. But the apparent misfortune was in one way a benefit since it provided an opportunity to study defective acoustics under exceptionally good conditions and led to conclusions that not only allowed the Auditorium to be improved but also indicate some of the pitfalls to be avoided in future construction of other halls.

An investigation of the acoustical properties of the Auditorium was begun in 1908 and has continued for six years. It was decided at the outset not to use "cut and try" methods of cure, but to attack the problem systematically so that general principles could be found, if possible, that would apply not only to the case being investigated but to auditoriums in general. This plan of procedure delayed the solution of the problem, since it became necessary to study the theory of sound and carry out laboratory investigations at the same time that the complex conditions in the Auditorium were being considered. The author spent one year of the six abroad studying the theory of acoustics and inspecting various auditoriums.

The main echoes in the Auditorium were located by means of a new method for tracing the path of sound, the time of reverberation was determined by Sabine's method, and a general diagnosis of the acoustical defects was made. Hangings and curtains were installed in accordance with the results of the study so that finally acoustical properties were improved.

II. BEHAVIOR OF SOUND WAVES IN A ROOM.

When a speaker addresses an audience, the sounds he utters proceed in ever widening spherical waves until they strike the boundaries of the room. Here the sound is partly reflected, partly transmitted, and the rest absorbed. The amounts of reflection, absorption and transmission depend on the character of the walls. A hard, smooth wall reflects most of the sound so that but little is transmitted or absorbed. In the case of a porous wall or a yielding wall, the absorption and transmission are greater, and the reflection is less. After striking a number of reflecting surfaces, the energy is used up and the sound dies out.

The reflection of sound produces certain advantages and disadvantages for the acoustics. When it is considered that sound travels about 1,100 feet a second it may be seen that a room of ordinary size is almost immediately filled with sound because of the many reflections. In a room 40 feet square, for instance, the number of reflections per second between opposite walls is 1,100 ÷ 40, or approximately 27. The number is really greater than this, since the sound that goes into the corners is reflected much more frequently than out in the middle where the distances between the walls are greater. The result is that the sound mixes thoroughly in all parts of the room so as to give the same average intensity; that is, the sound is of the same average *loudness* for all auditors, even for those in the remotest corners.

Though the reflection of sound has the advantage of fulfilling the conditions for loudness, it introduces at the same time possibilities for setting up defective acoustics. For instance, when the walls of the room are hard and smooth very little energy is lost at each impact of the sound and many reflections take place before it finally dies out. This slow decadence of the sound, or *reverberation* as it is called, is the most common defect in auditoriums.

If a speaker talks in such a hall the auditors have difficulty in understanding. Each sound, instead of dying out quickly, persists for some time so that the succeeding words blend with their predecessors and set up a mixture of sounds which produces confusion. The cure for the trouble is brought about by the introduction of materials such as carpets, tapestries, and the like, which act as absorbers of sound and reduce the time of reverberation.

When music is played in an auditorium with a prolonged reverberation, the tones following one another blend and produce the same effect as that of a piano when played with the loud pedal in use. A reverberation is more advantageous for music than for speech, since the prolongation and blending of the musical tones is desired, but the mixing of the words in a speech is a distinct disadvantage. When curing this defect for halls used for both music and speaking, a middle course must be steered, so that the reverberation is somewhat long for speaking and somewhat short for music, yet fairly satisfactory for both.

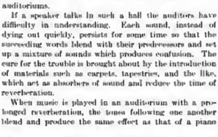


Fig. 1.—Interior view toward balcony.

Going back to the consideration of the reflection of sound, it is found that another defect may be produced, namely, an *echo*. This is the case when a wall at some distance reflects the sound to the position of the auditor. He hears the sound first from the speaker, then later by reflection from the wall. The time interval between the direct and reflected sound must be great enough to allow two distinct impressions to be made. This time is about 1/15 of a second, but varies with the acuteness of the observer. The farther off the wall is, the greater is the time interval and the more pronounced is the echo. If the wall is not very distant, the time interval is too short to allow two distinct impressions to be made, and the effect on the auditor is then much the same as if his neighbor at his side speaks the words of the discourse in his ear at the same time that he gets them directly from the speaker. In case the reflecting wall is curved so as to focus the sound the echoes are much more pronounced. A curved wall wherever it may be placed in an auditorium is thus always a menace to good acoustics.

There are other actions of the sound that may result in acoustical defects. The phenomena of *resonance*, for instance, may cause trouble. Suppose that the waves of sound impinge on an elastic wall, not too rigid. If these waves are timed right they set the wall in vibration in the same way that the bell ringer causes a bell to ring by a succession of properly timed pulls on the bell rope. The wall of the room will then vibrate under the action of this sound with which it is in tune and will reinforce it. Now suppose a band is playing in a room. Certain tones are reinforced, while the others are not affected. The original sound is then distorted. The action is the same on the voice of the speaker. The sounds he utters are complex and as they reach the walls certain components are reinforced and the quality of the sound is changed. This action of resonance may also be caused by the air in a room. Each room has a definite pitch to which it responds, the smaller the volume of the room the higher being the pitch. A large auditorium would respond to the very low pitch of the bass drum. In small rooms and alcoves the response is made to higher pitched tones, as may be observed by singing the different notes of the scale until a resonance is obtained.

Another action of sound causes the *interference of waves*. Thus the reflected waves may meet the oncoming ones and set up concentrations of sound in certain positions and a dearth of sound in others.

Summing up, it is seen that the effects of sound which may exist in a room are *loudness, reverberation, echoes, resonance*, and *interference*, and that the most common defects are reverberation and echoes. We now turn to the discussion of the methods of the cure.

III. METHODS OF IMPROVING FAULTY ACOUSTICS.

A. REVERBERATION AND ITS CURE.

Everyone has doubtless observed that the hollow reverberations in an empty house disappear when the house is furnished. So, in an auditorium, the reverberation is lessened when curtains, tapestries, and the like are installed in sufficient numbers. The reason for this action is found when we inquire what ultimately becomes of the sound.

Sound is a form of energy and energy can not be destroyed. When it finally dies out, the sound must be changed to some other form of energy. In the case of the walls of a room, for instance, it has been shown in a preceding paragraph that the sound may be changed into mechanical energy in setting those walls in vibration. Again, some of the sound may pass out through open windows and thus disappear. The rest of the sound, according to Lord Rayleigh, is transformed by friction into heat. Thus[1] a high pitched sound, such as a hiss, before it travels any great distance is killed out by the friction of the air. Lower pitched sounds, on reaching a wall, set up a friction in the process of reflection between the air particles and the wall so that some of the energy is converted into heat.[2] The amount of sound energy thus lost is small if the walls are hard and smooth. The case is much different, however, if the walls are rough and porous, since it appears that the friction in the pores dissipates the sound energy into heat. In this connection, Lamb[3] writes: "In a sufficiently narrow tube the waves are rapidly stifled, the mechanical energy lost being of course converted into heat. * * * * When a sound wave impinges on a slab which is permeated by a large number of very minute channels, part of the energy is lost, so far as the sound is concerned, by dissipation within these channels in the way just explained. The interstices in hangings and carpets act in a similar manner, and it is to this cause that the effect of such appliances in deadening echoes in a room is to be ascribed, a certain proportion of the energy being lost at each reflection. It is to be observed that it is only through the action of true dissipative forces, such as viscosity and thermal conduction, that sound can die out in an enclosed space, no mere modifications of the waves by irregularities being of any avail."

It should be pointed out in this connection that any mechanical breaking up of the sound by relief work on the walls or by obstacles in the room will not primarily diminish the energy of the sound. These may break up the regular reflection and eliminate echoes, but the sound energy as such disappears only when the friction is set up.

The following quotation from Rayleigh[4] emphasizes these conclusions: "In large spaces, bounded by non-porous walls, roof, and floor, and with few windows, a prolonged resonance seems inevitable. The mitigating influence of thick carpets in such cases is well known. The application of similar material to the walls and roof appears to offer the best chance of further improvement."

Experimental Work on Cure of Reverberation.—The most important experimental work in applying this principle of the absorbing power of carpets, curtains, etc., has been done by Professor Wallace C. Sabine of Harvard University.[5] In a set of interesting experiments lasting over a period of four years, he was able to deduce a general relation between t, the time of reverberation, V, the volume of the room, and a the absorbing power of the different materials present. Thus:

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* Abstract of Bulletin 73, of the Engineering Experiment Station. Published by the University of Illinois.

[1] "Theory of Sound," Vol. II, p. 316.

[2] "Theory of Sound," Vol. II, p. 331.

[3] "Dynamical Theory of Sound," p. 190.

[4] "Theory of Sound," p. 333.

[5] "Architectural Acoustics." A series of articles in the Engineering record, 1900, also the American Architect, 1900.

$$t=0.164\,V \div a \qquad (1)$$

For good acoustical conditions, that is, for a short time of reverberation, the volume V should be small and the absorbing materials, represented by a, large. This is the case in the small room with plenty of curtains and rugs and furniture. If, however, the volume of the room is great, as in the case of an auditorium, and the amount of absorbing materials small, a troublesome reverberation will result.

Professor Sabine determined the absorbing powers of a number of different materials. Calling an open window a perfect absorber of sound, the results obtained may be written approximately as follows:

One square meter of open window space	1.000
One square meter of glass, plaster, or brick......	.025
One square meter of heavy rugs, curtains, etc....	.25
One square meter of hair felt, 1 inch thick ..	.75
One square meter of audience..................	.96

These values, together with the formula, allow a calculation to be made in advance of construction for the time of reverberation. This pioneer work cleared the subject of architectural acoustics from the fog of mystery that hung over it and allowed the essential principles to be seen in the light of scientific experiment.

In a latter investigation[6] Sabine showed that the reverberation depended also on the pitch of sound. As a concrete example, the high notes of a violin might be less reverberant with a large audience than the lower tones of the bass viol, although both might have the same reverberation in the room with no audience. Again, the voice of a man with notes of low pitch might give satisfactory results in an auditorium while the voice of a woman with higher pitched notes would be unsatisfactory.

These considerations show that the acoustics in an auditorium vary with other factors than the volume of the room and the amount of absorbing material present. The audience may be large or small, the speaker's voice high or low, the entertainment a musical number or an address. The best arrangement for good acoustics is then a compromise where the average conditions are satisfied. The solution offered by Professor Sabine is such an average one, and has proved satisfactory in practice.

The problem of architectural acoustics has been attacked experimentally by other workers. Stewart[7] proposed a cure for the poor acoustical conditions in the Sibley Auditorium at Cornell University. His experiments confirmed the work of Sabine. Marage[8], after investigating the properties of six halls in Paris, approved Sabine's results and advocated a time of reverberation of from ½ to 1 second for the case of speech.

Formulae for Reverberation of Sound in a Room.—On the theoretical side, Sabine's formula has been developed by Franklin[9], who obtained the relation $t=0.1625V \div a$, an interesting confirmation, since Sabine's experimental value for the constant was 0.164.

A later development has been given by Jäger[10], who assumes for a room whose dimensions are not greater than about 60 feet, that the sound, after filling the room, passes equally in all directions through any point, and that the average energy is the same in different parts of the room. By using the theory of probability and considering that a beam of sound in any direction may be likened to a particle with a definite velocity, he was able to deduce Sabine's formula and write down the factors that enter into the constants. Applying his results to the case of reflection of sound from a wall, he showed that sound would be reflected in greater volume when the mass of the wall was increased and the pitch of sound made higher. He showed also that when sound impinges on a porous wall, more energy is absorbed when the pitch of the sound is high than when it is low, since the vibrations of the air are more frequent, and more friction is introduced in the interstices of the material.

B. ECHOES AND THEIR REMEDY.

An echo is set up by a reflecting wall. If an observer stands some distance from the front of a cliff and claps his hands, or shouts, he finds that the sound is returned to him from the cliff as an echo. So, in an auditorium, an auditor near the speaker gets the sound first directly from the speaker, then, an instant later, a strong repetition of the sound by reflection from a distant wall. This echo is more pronounced if the wall is curved and the auditor is at the point where the sound is focused.

To cure such an echo, two methods may be considered. One method consists in changing the form of the wall so that the reflected sound no longer sets up the echo. That is, either change the angle of the wall, so that the reflected sound is sent in a new direction where it may be absorbed or where it may reinforce the direct sound without producing any echoes, or else modify the surface of the wall by relief work or by panels of absorbing material, so that the strong reflected wave is broken up and the sound is scattered. The second method is to make the reflecting wall a "perfect" absorber, so that the incident sound is swallowed up and little or none reflected. These methods have been designated as "surgical" and "medicinal" respectively. Each method has its disadvantages. Changing the form of the wall in an auditorium is likely to do violence to the architectural design. On the other hand, there are no perfect absorbers, except open windows, and these can seldom be applied. The cure in each case is, then, a matter of study of the special conditions of the auditorium. Usually a combination of the surgical and the medicinal cures is adopted. For instance, coffering a wall so that panels of absorbing material may be introduced has been found to work well in bettering the acoustics, and also, in many cases, it fits in with the architectural features.

C. POPULAR CONCEPTION OF CURVES.—USE OF WIRES AND SOUNDING BOARDS.

A few words should be written concerning the popular notion that wires and sounding boards are effective in curing faulty acoustics. Experiments and observations show that the wires are of practically no benefit, and sounding boards can be used only in special cases. Wires stretched in a room scarcely affect the sound, since they present too small a surface to disturb the waves. They have much the same effect on sound waves that a fish line in the water has on water waves. The idea has, perhaps, grown into prominence because of the action of a piano in responding to the notes of a singer. The piano has every advantage over a wire in an auditorium. It has a larger number of strings tuned to different pitches so that it responds to any note sung. It also has a sounding board that reinforces strongly the sound of the strings. Finally, the singer is usually near the piano. The wire in the auditorium responds to only one tone of the many likely to be present, it has no sounding board, and the singer is some distance away. But little effect, therefore, is to be expected.

The author has visited a number of halls where wires have been installed, and has yet to find a case where pronounced improvement has resulted.[11] Sabine[12] cites a case where five miles of wire were stretched in a hall without helping the acoustical conditions. It is curious that so erroneous a conception has grown up in the public mind with so little experimental basis to support it.

Sounding Boards.—Sounding boards or, more properly, reflecting boards, have value in special cases. Some experiments are described later when pronounced effects were obtained. The sounding board should be of special design to fit the conditions under which it is to be used.

Modeling New Auditoriums after Old Ones with Good Acoustics.—Another suggestion often made is for architects to model auditoriums after those already built that have good acoustical properties. It does not follow that halls so modeled will be successful, since the materials used in construction are not the same year after year. For instance, a few years ago it was the usual custom to put lime plaster on wooden lath; now it is frequently the practice to put gypsum plaster on metal lath, which forms an entirley different kind of a surface. This latter arrangement makes hard, non-porous walls which absorb but little sound, and thus aggravate the reverberation. Further, a new hall usually is changed somewhat in form from the old one, to suit the ideas of the architect, and it is very likely that the changes will affect the acoustics.

D. THE EFFECT OF THE VENTILATION SYSTEM ON THE ACOUSTICS.

At first thought it might seem that the ventilation system in a room would affect the acoustical properties. The air is the medium that transmits sound. It has been shown that the wind has an action in changing the direction of propagation of sound.[13] Sound is also reflected and refracted at the boundary of gases that differ in density and temperature.[14] It is found, however, that the effect of the usual ventilation currents on the acoustics in an auditorium is small. The temperature difference between the heated current and the air in the room is not great enough to affect the sound appreciably, and the motion of the current is too slow and over too short a distance to change the action of the sound to any marked extent.[15]

Under special circumstances, the heating and ventilating systems may prove disadvantageous.[16] A hot stove or a current of hot air in the center of the room will seriously disturb the action of sound. Any irregularity in the air currents so that sheets of cold and heated air fluctuate about the room will also modify the regular action of the sound and produce confusion. The object to be striven for is to keep the air in the room as homogeneous and steady as possible. Hot stoves, radiators, and currents of heated air should be kept near the walls and out of the center of the room. It is of some small advantage to have the ventilation current go in the same direction that the sound is to go, since a wind tends to carry the sound with it.

(*To be concluded.*)

The Widening Pellagra Zone*

The recent studies of pellagra, and exhaustive reports such as that of the Thompson-McFadden Pellagra Commission, have undoubtedly resulted in the discovery of many obscure cases of this disease which otherwise would have escaped detection. This statement probably applies to a greater extent in the regions that are supposed to be outside the focal pellagra zones than in places where the disease is of common occurrence. Nevertheless, the number of cases that have been reported at points remote from the focal centers, and the fact that many of the conditions attending these cases do not conform to the observations made in the South, force the conclusion that the disease is not only increasing its territory, but is invading classes that have hitherto remained practically immune.

It is possible, of course, that even in remote districts, where pellagra seems only recently to have made its appearance, the disease is not really such a novelty, but simply that it has not been recognized heretofore. This is a reasonable supposition, particularly as regards the milder or abortive type of cases. But it can hardly be true of the virulent types. And the natural conclusion is, since well-marked cases are now making their appearance in districts that seem to have escaped hitherto, that the disease is extending its zone of operation.

The report of the Thompson-McFadden Commission indicates that the disease is usually the concomitant of malnutrition, poverty, and bad hygiene. "In our opinion," says this report, "the view that pellagra is an intestinal infection, transmitted by contaminated food, to which the individual is rendered more susceptible by malnutrition, poorly selected or poorly prepared food and by the common gastro-intestinal disturbances resulting from errors in diet, is a conception worthy of further study."

In most of the cases of this disease that have come under our observation recently the conditions referred to in this report did not prevail, although all of them presented the typical picture of pellagra itself.

According to the Thompson-McFadden Commission observers the disease is peculiarly prevalent among women between the ages of nineteen and forty-five, whereas the rate of prevalence among males drops very appreciably at this time of life. The exact amount of this decline is shown by the fact that, although the rate of prevalence is practically equal in the two sexes among children under ten and among adults over forty-five years of age, in the intervening period the proportion of women afflicted is about four to one.

But perhaps the most interesting single feature presented by the cases brought to our attention in this vicinity, is the fact that they occurred among a class of persons representing a very different economic status from the majority of cases observed by the Thompson-McFadden Commission. And the reports of cases in Los Angeles seem to indicate that the patients were largely those from the better walks of life, or at least were persons accustomed to good food and hygienic surroundings of the middle classes.

Certainly the economic condition of these cases contrasts strikingly with those reported by the Thompson-McFadden Commission observers. For these observers report that 85 per cent of cases occurred among people of insufficient means, who were eating poor, badly prepared food, and where general economic conditions were bad. Probably their findings are distinctly influenced by the relatively high percentage of poverty in the regions under investigation. But in any event it is interesting and significant that the cases seen in Southern California taken collectively refute the old idea that pellagra is largely a "filth disease." Or at least they show that, if the disease was formerly only the accompaniment of poverty, affecting the lower classes, it is now extending its attacks to the more favored strata of society.

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[6] "Architectural Acoustics." Proc. of Amer. Acad. of Arts and Sciences, Vol. 42, pp. 49-84, 1906.

[7] G. W. Stewart. "Architectural Acoustics." Sibley Journal of Engineering, May, 1903. Published by Cornell University, Ithaca, N. Y.

[8] "Qualités acoustiques de certaines salles pour la voix parlée." Comptes Rendus, 142, 878, 1906.

[9] W. S. Franklin. "Derivation of Equation of Decaying Sound in a Room and Definition of Open Window Equivalent of Absorbing Power." Physical Review, Vol. 16, pp. 372-374, 1903.

[10] G. Jäger. "Zur Theorie des Nachhalls." Sitzungsberichte der Kaiserliche Akad. der Wissenschaften in Wien, Math-naturw. Klasse, Bd. CXX. Abt. II a. Mai 1911.

[11] Science of Vol. 35, p. 833, 1912.

[12] Arch. Quarterly of Harvard University, March, 1912.

[13] Osborne Reynolds. Proc. of Royal Soc. Vol. XXII., p. 531, 1874.

[14] Joseph Henry. "Report of the Lighthouse Board of the United States for the year 1874."

J. Tyndall. Phil. Trans., 1874.

[15] Sabine Engineering Record, Vol. 61, p. 779, 1910. Watson, Engineering Record, Vol. 67, p. 265, 1913.

[16] Sabine and Watson. Ibid.

* From the Medical Record.

Men's recreation grounds at the Cadbury Works, Bournville, England.

Lawn tennis grounds at Port Sunlight, England.

The Welfare of Workmen in European Enterprises

Improved Housing Provided, and Health and Social Conditions Considered

By C. Van Langendonck

In these days of great competition, especially in the engineering and other allied trades, many firms are alive to the necessity of up-to-date plants; comparatively few of them, however, realize the extent to which the workman's environment affects him and his work.

Experience has, however, proved that frequently a large measure of the success of an enterprise is due to the conditions under which the employees do their work, and the companies who have spent time and money in improving the environment of their workpeople have almost invariably obtained good results.

The justification for securing the welfare of the employee is twofold: First there is the moral obligation of the employer to provide conditions of work that tend to the comfort, moral welfare and self respect of the employed. Secondly, there is the advantage of promoting a cordial attitude on the part of the workmen toward the employer.

We know that great progress in welfare work has been made in American factories. The present article refers only to what the old world has done for insuring a convenient life and agreeable surroundings for their people.

For the sake of convenience, we will group the various features of work under the heads of Health, Recreation and Education, and Housing:

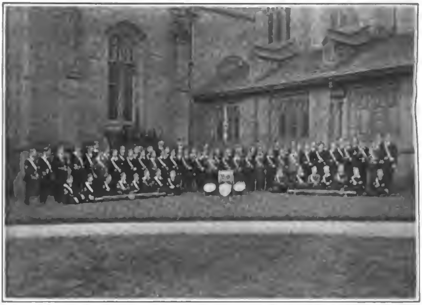
Health.—Under this head, which is the first that should concern the employer of labor, there are two distinct fields for operation: that of the preserving of the workers' health, and that of dealing with their various ailments.

Convenience for the supply of meals for workers living at a distance, the supply of fresh and good fruit at cheap rates, the reduction of the working hours to the lowest possible limit, readily suggest themselves. In addition to lofty and spacious rooms, various contrivances may be introduced for securing abundance of pure air.

It is an undisputed fact that the workman's health is greatly affected by his surroundings, and this, it must be borne in mind, does not end with the present working generation, but must have an influence upon the children who, in time to come, will have to take their fathers' places.

Many European employers have made provision for giving their people opportunity for decently eating a lunch in special factory rooms or restaurants. In most cases arrangements are made for selling at very low prices, good hot coffee or other soft drinks and warm food. Other installations make it possible to warm food brought from home. In the case of married men, for instance, some employers offer the food below cost and think themselves recompensed in other ways. The distribution of prepared food presents no special difficulties, and our photographs show how this is done in the works of Messrs. Cadbury Bros., Bournville (England), and Messrs. Lever Bros. Several large works have their own doctor whose whole time is at the service of the employees.

In many instances lavatories, lockers, dressing and other decent sanitary and toilet conveniences are pro-



Boys' brigade and bugle bands at the works of Messrs. Lever Brothers, at Port Sunlight, England.

Girls' dining room, Port Sunlight, England.

Gymnasium at Bournville, England.

The ambulance brigade at Port Sunlight.

Girls' recreation grounds at Bourneville.

vided. No one will dispute that a workman has a right to go home with clean clothes as well as clean face and hands. Further, it is recognized that the number of deaths caused by diseases and illnesses is at least as important a question as that of deaths due to accidents; and in providing comfortable washing and changing accomodation, many lives are spared every year. In numerous works provision is made to deal quickly and efficiently with any cases of sickness which might occur. There are ambulance boxes in different parts of the works, fitted up with the necessary appliances and clear instructions for use.

Recreation.—Much coming under this division deserves a place under the previous one, since the inducements to engage in physical exercises and health-giving games tend to maintain a high standard of health. Experience has demonstrated that the workpeople are showing much enthusiasm for recreation institutions and love to take their recreation in common. Several large European works have their own flourishing recreation clubs. Worthy of notice among others, are the extensive recreation grounds adjoining the works of Messrs. Cadbury: one for women and one for men. These grounds, each of about 12 acres, are laid out to meet the modern requirements of cricket, football, hockey, and other games. It may be said that the development of these sporting games is a powerful factor in the bringing together of the classes. Once in football costume, for instance, the distinction of proletarian and millionaire, workman and foreman, no longer exists.

Chiefly in England, magnificent baths are found annexed to the works. The managing staff have felt that with opportunities for regular weekly bathing and learning to swim, the working people would not only be stronger and healthier, but personal hygiene would be kept to a higher standard.

Education.—One of the most important means of social uplifting is the institution of youths' clubs. If the social and educational welfare of the young generation received a more careful superintendence, it is certain many of the social problems, which at present press for solution, would no longer arise. None need the attention of the welfare worker more than the generation in which the hope of the future is centered, and no institution will have more to show for its existence, both in the present and the future, than these clubs whose members, it may be presumed, will some day be holding positions of responsibility with the firms who employ them. These club-houses generally contain reading rooms, library, bagatelle room, class room, cooking school for young women, museums, etc.

A serious feature of welfare work, and one which it is expected many employers of labor will take up in the future, is the offer made by firms to pay a portion of the evening technical education fees of the younger employees. In several instances, classes are also held directly in connection with the works. In various works encouragement is given to employees to make suggestions for the increased comfort of the workpeople, or for any improvements in the methods adapted for dealing with the work; and cash prizes are awarded for such suggestions as meet with approval.

General.—In many instances all employees of the same enterprise are members of a general sick club in the works and are thus sure of a regular allowance when ill. Often special sections provide for the payment of a weekly sum to any members who are by rule bound to leave the works when an outbreak of infectious disease takes place in their homes. Numerous works have their own hospital, where the services are quite gratuitous.

Mention should be made of the savings funds, where the employees may deposit money, receiving interest averaging between 4 and 5 per cent per annum; and the pension schemes, the funds of which are provided partly by the companies and partly by weekly or monthly deductions from the wages of the subscribers. In several cases committees, including representatives of the workpeople, are appointed to relieve the directorate of the matters affecting the funds.

Housing Problem.—Of prime importance is the housing problem. Too often the working people are compelled to live under conditions which are a scandal to our civilization. These are housed in close, dirty, evil-smelling lanes and courts, deprived of fresh air and sunshine; strangers to the sight of grass and flowers and trees, and without opportunity for healthy recreation. All this inevitably tends to produce moral and physical deterioration.

Several important European firms have made a most successful study of this problem, and some of our illustrations give views of the really beautiful homes provided.

On entering these workmen's villages, the visitor is charmed by its beauty and perfect harmony. Generally the houses are built in groups, with three to nine houses in each group at most, and there are no two groups alike. The roads are very wide, and trees, verdure and small parks are to be seen in every direction. The majority of the houses have two sitting rooms, a kitchen or scullery, three bedrooms, and the usual conveniences. There are others with one large living room instead of two smaller ones, and a few with only two bedrooms.

Every house has its garden, and, in addition, every inhabitant can have a nearby allotment garden to cultivate. As a rule the tenants take a keen interest in their gardens, and cultivate them with great success.

The beautiful and substantially-built cottages with their low rentals, the trimly-kept lawns and gardens, the facilities generally offered for the free education of the children; the fact that, as a rule, the sale, distribution or consumption of intoxicating liquor is suppressed, show at first glance that the conditions under which the inhabitants of these communities live are far superior to those enjoyed by the great majority of the workpeople.

Modern Electric Protective Devices

In the modern electric generating station the protective devices represent the highest class of design and workmanship in the entire installation, while the cost of the switchboard frequently nearly equals that of the plant controlled by it. In the old days, however, says J. Gardner, writing in *Vulcan*, few or no protective devices were installed. For instance, in a power station still running there are several 2,000-volt 300-kilowatt single-phase generators controlled by open single-pole switches of the simplest type and without even a fuse in circuit; one side of the system is earthed. Everything operates quite satisfactorily until a cable goes to earth or someone makes a mistake; then there is a serious accident. A case of this kind recently occurred. A direct-current generator coupled to a steam engine was being run up in readiness for paralleling with other machines. When the volts were about one hundred the attendant closed the main switch of this machine by mistake. Although the fault was discovered immediately, the rush of current into the machine pulled the armature winding partly round the core, and some of the commutator segments were nearly forced out of the "V" rings. The driving pins in the armature were sheared off and the insulation of the core was damaged. The armature had to be entirely re-wound and the commutator rebuilt.

Cottages at Port Sunlight, England.

A dinner hour scene—cricket is popular with the girls.

Rail Sections as An Element in Steam and Electric Traction—I*

Early History of Track Construction and Developments Made Possible

By P. H. Dudley, C.E., Ph.D., Consulting Engineer, New York Central Lines, New York

THE 6-inch 100-pound steel rail section, laid first in 1892 on the New York Central & Hudson River Railroad, was designed with a broad thin head for an ample bearing surface of the wheel treads on a stiff rail, which could distribute a large portion of their loads to the wheel spacing for a smooth riding track. The fact is not generally appreciated that the wheel load spacing of the equipment controls the spans of the bending rails on the flexible crossties in the ballast, rather than their spacing under the rail. It was, as a rail section of that date, the most efficient engineering structure in use in the world and has fulfilled its complex functions with safety, precision, and economy as an essential element of the means of railway transport. (See Fig. 8.)

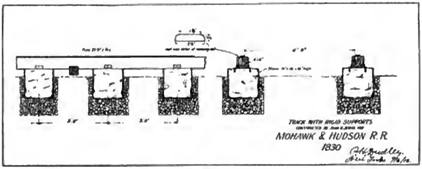


Fig. 1.

The modern steel trains, the Empire State Express, the Twentieth Century Limited and others, each have a kinetic energy greater than the heaviest projectile of any high power guns yet fabricated. The stored energy for the speed of the train can be absorbed and rendered inert through several wheel contacts on the rails, when the engineer touches the handle of the air brakes to stop his train. The artillerist concentrates the stored energy of a projectile upon a single contact for destructive effect, while the railway engineer carries and distributes the total load of a train on many wheels, and therefore absorbs the stored energy for the speed of the train through several contacts on the rails for safety and utility. The weight of the rails on their flexible crosstie supports in the ballast and subgrade, occupied by the length of the steam railway or multiple unit train on its several wheels, may be but one-hundredth of the load which the rails can carry when subdivided, distributed, and constrained through several wheel contacts. A rail of suitable stiffness on the flexible crossties in the ballast, due to the principle or efficiently subdivided, distributed and constrained loads, is better for good track, smooth riding of the equipment, and economical operation, than that of the major part of the wheel loads concentrated on each crosstie, through a weak rail section.

The 6-inch 100-pound section is a model of efficiency through its metal to limit and distribute the reduced strains of its wheel loads to the crosstie supports, for it can withstand thousands of repetitions with marvelous exactness for similar conditions of service without failure.

SOME INTERESTING HISTORIC DEVELOPMENTS IN TRANSPORTATION.

Schenectady being in the valley of least resistance to travel from east to west and *vice versa*, inherited the Indian trail and canoe, then developed transportation, by (1) the Conestoga wagon, (2) the stage coach, (3) the canal, (4) steam railroads, (5) electric traction.

The Mohawk & Hudson Railroad from Schenectady to Albany was chartered in 1826, although active work upon its construction did not commence until 1830 and 1831 for the Saratoga & Schenectady Railroad. Mr. John B. Jervis was chief engineer of both roads for construction. Locomotives were then in their primitive stage of evolution, of small tractive effort, and able to ascend only moderate gradients of a few feet per mile. Mr. Jervis was therefore obliged to construct for the Mohawk & Hudson Railroad an inclined plane operated by a stationary engine, for the ascent and descent of the cars at Schenectady, from the Mohawk River to the plateau on its banks. A similarly inclined plane was constructed from the Hudson River for the Albany terminal. The alinement of the track of the Mohawk & Hudson Railroad for 14 miles on the plateau was composed of three tangents connected by two curves. The one about midway of the line was 396 feet long and of 23,000 feet radius; the second, near Albany, was 591 feet long and of 4,200 feet radius. The head of each inclined plane connected with the tangent at either end by a curve 528 feet long and of 1,100 feet radius. To make the gradients and curves easy for the locomotives, the cuts and fills were heavy, and the cost of the railroad averaged $40,228 per mile, a large sum for 1831, but a small cost for the principles elucidated.

The New York Central & Hudson River Railroad now occupies the original line from Carmen to Karner, and includes the curve of 23,000 feet radius. The total length of the railroad at first was 15.86 miles, and it did not run into the business portion of the capital; but later a branch line for passengers was permitted in State Street. New York State had just completed its Erie Canal, and the Mohawk & Hudson Railroad Company at first was not allowed to transport freight.

We can study with profit the historic but frail structures of the track, the primitive locomotives and the strap iron rails for the principles of construction which eventually directed their evolution into types in eighty-three years for the present developments. This has required the application of the facts of experience and the principles of science of the preceding ages, on a more extensive scale than ever before in the history of mankind.

The superstructure of the track for the Mohawk & Hudson Railroad on the plateau between the inclined planes at Schenectady and Albany was constructed of a strap iron rail, 2½ inches wide and $\frac{9}{16}$ of an inch thick, with the upper corners rounded to 1¾ inches and spiked in the center of longitudinal stringers 6 by 6 inches, for their strength as a girder, Fig. 1. The author has one of the original rails and a piece of a stringer. To make an expected enduring track of rigid supports in the roadbed, pits 2 feet square and with 3-foot centers were prepared for each line of stringers, and in each pit were placed about nine cubic feet of broken stone which cost $2 per cubic yard. Near Schenectady, to support the stone blocks, the broken stone was placed in two parallel trenches. Some blocks were placed on these foundations, each of 2½ cubic feet, 16 inches in height, with a top surface of 15 by 16 inches, and upon these stringers were laid and attached by knees and spikes to support the strap iron rails. The iron formed the bearing surface for the wheel contacts and the guide for the flanges of the wheels of the passing locomotives and cars, and the stringer as a separate piece supplied the strength as a girder.

Mr. Jervis opened the Mohawk & Hudson Railroad August 9th, 1831, with the locomotive "DeWitt Clinton," which was carried upon two pairs of drivers and weighed 6,758½ pounds, and was intended to be under three gross tons, exclusive of the light four-wheeled tender. The three cars were stage coach bodies with flanged wheels for the track. The length of the entire train was less than that of one of the present Pacific types of locomotives.

A locomotive named the "John Bull" was built by Robert Stephenson & Son, Newcastle-upon-Tyne, and weighed 12,742 pounds and had under the front end a pair of rigid carrying wheels, while the single pair of driving wheels carried 8,745 pounds. The wheels of both locomotives were 4 feet 8 inches in diameter, and the wheel base of each, 4 feet 6 inches. The weight of the "John Bull" was too great for the superstructure, and was not subdivided and distributed by a wheel base sufficient in length to ride steadily over the track, and was seldom used as originally made.

Mr. John B. Jervis was constructing the Saratoga & Schenectady Railroad when he opened the Mohawk & Hudson. Three miles of track were finished with stone blocks set upon broken stone, which carried the stringers, the same as used for the Mohawk & Hudson Railroad. The strap rail was an angle iron spiked on the upper inner corners for the track, to provide for inch flanges on the engine drivers and wheels. Mr. Jervis built the balance of the line with crossties upon which the stringers were placed to support the small angle strap iron rails, and ballasted the track for the flexible superstructure and an elastic roadbed, the principle in use to-day on all steam railroad tracks. The design of the superstructure of the track of the Mohawk & Hudson Railroad on the rigid supports is shown in Fig. 1, and the Saratoga & Schenectady Railroad on elastic supports in Fig. 2, from the best information to date. Fig. 3 shows the original English locomotive "John Bull," by Robert Stephenson & Co., 1831.

Mr. Jervis found the engines were more severe upon the strap iron rails of the Mohawk & Hudson Railroad than was expected, and in 1832 he designed his leading four-wheel truck, arranged for both lateral and vertical flexibility to guide the front of the locomotive in place of the ordinary carrying pair of wheels of the English construction (see Fig. 4). This was also to extend the running gear of the engine, to subdivide and distribute the front truck load on the rail for the following driving wheels. The wheel base of the engine constructed on this important principle was found much easier upon the track and was extensively copied, and in a few years another pair of driving wheels was added for new engines, constituting the American eight-wheel or 4-4-0 type of engine.

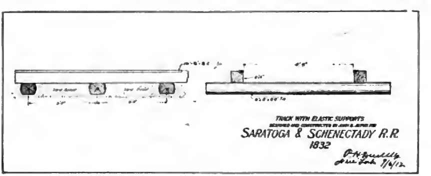


Fig. 2.

The locomotive in evolution had now reached a type capable of enlargement, so flexible in the wheel base as to carry sufficient weight on the driving wheels for adhesion to pass around sharp curves and ascend gradients of 10 feet per mile, and superseded the inclined planes worked by stationary engines, used in the earlier railways.

My tribute to the enduring work of Mr. Jervis on the

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* Courtesy of the *General Electric Review*.

Mohawk & Hudson Railroad, for all coming time, is for his adoption and practice of the principle involved in the leading four-wheel truck for flexibility, and extension of the wheel base of the locomotive for subdivided, distributed and constrained wheel loads on the rails, crossties, ballast, and subgrade. The practice of the principle of a flexible superstructure on an elastic roadbed, used on the Saratoga & Schenectady Railroad, is now followed by all steam railways of the world.

IRON TEE RAIL SECTIONS.

Robert Livingston Stevens in 1830 designed for the Camden & Amboy Railroad a section of rail, the principle of which combined in one piece the bearing surface for the wheel treads, the guide for the wheel flanges, and the strength for the girder, with a base to rest upon and be spiked to the crossties. This was the prototype of our present rail sections, and was rolled in 1831 by Guest & Co. of Wales. It did not come into general use on account of the expense for many years, and then the head was made more pear-shaped. The construction of the early railways with iron rails was slow, for at first all the iron used was imported from England or Wales.

There were only 23 miles of railway track in this country in 1830 composed of strap iron rails laid upon wooden or stone stringers, and only increased to 2,818 miles in 1840, as the frail superstructure of the track had not taken suitable form for its development; and strap iron rails were prohibited by law in New York State in 1844. The physical properties of wrought iron were sufficient for the installation of the early railways but inadequate for their development.

BESSEMER'S INVENTION FOR MAKING STEEL.

Bessemer steel replacing iron rails marks a distinct epoch in the construction of mileage, maintenance, and operation of railways. Bessemer's grand conception was the application of the fact that one half of one per cent of carbon combined with iron made a ductile steel of greater physical properties than wrought iron, and as cast iron contained from 3½ to 4 per cent of carbon, 1.25 to 2.5 per cent of silicon, 0.50 to 1 per cent of manganese, 0.03 to 0.06 of phosphorus, a non-ductile and brittle product, he made a suitable converter and blew air through the bath of molten cast iron to burn out, first, the silicon and manganese, then the excess carbon above that desired for his grade of steel. This direct method proved only possible with the nearly pure Swedish irons. It was required in all other countries to select pig iron in which the impurities of phosphorus and sulphur would be 0.1 or under, as required for the grade of steel, and then decarburize the molten bath by blowing air through it and subsequently recarburize the blown metal with the desired carbon, manganese, and silicon contents. This was a success, and, by the large product which could be made, rendered possible the present railway development by the use of steel rails of greater physical properties and more homogeneous product, to replace those of iron of inadequate physical properties.

The use of Bessemer steel rails commenced in this country in 1863, with imported English brands of 500 to 1,000 tons for trial. The early rails cost $100 to $120 gold per ton, which, with the premium, made the cost from $240 to $260 in currency during the civil war. The early Bessemer steel rail sections were from 3½ to 4½ inches high, and the weights ranged from 56 to 60 pounds per yard.

The engineers of the New York Central & Hudson River Railroad made deflection tests and in 1870 increased the height of the rails to 4½ inches, and the weight of the section from 60 to 65 pounds per yard. Large tonnages of the 65-pound section were rolled in England and France, and the third and fourth tracks were laid with it about 1870 and 1871, and cost from $100 to $110 per ton. These early steel rails were so expensive that the weights of the sections were rolled as light as was considered safe for service. They were not stiff, and had small mechanical properties, and deflected to a marked extent under the wheels, and transmitted concentrated instead of distributed loads to each crosstie. A committee of the American Society of Civil Engineers, in 1873, studying the small wear of the rail under the light wheel loads, came to the conclusion that it would be desirable to design for economical reasons what was termed a residual section, and then add sufficient metal to the top of the head for several years' wear (see Fig. 5). They modified entirely the type of the section, reduced the percentage of the metal in the base and used more in the deep head, providing, as they supposed, for many more years' duration. The question of a section as an engineering structure for stiffness to reduce the train resistance and maintenance was not considered, as it was in advance of the ideas of the evolution of rail sections at that date.

The deep, heavy head, and the change from the thick to the thin base, did not make as safe a girder for heavy traffic, nor result in an equal quality of metal in the rail, as had been secured in the shallow head and thick base of the early sections, to which type we are now reverting from experience, for superior girders. The light steel rails, however, enabled the railway companies to save the cost of renewing the iron rails so often, and lessened the operating expenses, though it did not permit much increase in the wheel loads of the locomotives and cars over those used upon the iron rails. The railway officials were anxious to improve their tracks and increase the wheel loads of the motive power and equipment to run faster and heavier express trains, and also haul larger freight train loads. I made a track indicator, with a special six-wheel truck, to measure and record autographically the undulations of the rails in the tracks, to determine what was necessary to improve them in an economical manner.

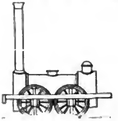


Fig. 3.—"John Bull" locomotive on the Hudson and Mohawk Railway, 1831. Built by Robert Stephenson & Son.

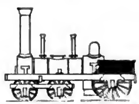


Fig. 4.—First bogie engine, Saratoga and Schenectady Railway. Jervis' four-wheel front truck engine, built by Robert Stephenson & Company, 1833.

INSPECTION OF TRACKS WITH TRACK INDICATOR.

I commenced the investigation of the undulation of the rails by my track indicator in 1879. The New York Central at that time had 4½-inch 65-pound steel rails (see Fig. 5) in general use upon the main lines, and upon some of the subsidiary lines, 56 and 60-pound, and the height was from 4 to 4½ inches. The Boston & Albany had a 4½-inch 72-pound, and the Pennsylvania, two sections of 4½-inch 67-pound.

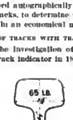


Fig. 5.—New York Central and Hudson River Railroad, 1870.

The diagrams taken from over 10,000 miles of the Eastern lines demonstrated the fact that the rails did not have sufficient mechanical properties to distribute the loads in the wheel spacing to any marked extent, as each crosstie received nearly the major percentage of the wheel effects. The crossties cut under the rail seats with rapidity, which permitted the light equipment to cause destructive, expensive and useless injury, while the train resistance was high, as well as the cost of maintenance and operation. I added a mechanism in 1881 to sum up the undulations into feet and inches, shown on the large diagrams, of 1 inch in length of paper to 50 feet of track, from which the amount per mile and section was secured for tabulation, and afforded definite measures of what labor could do and what could be expected from stiff rails in the track.

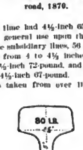


Fig. 6.—New York Central and Hudson River Railroad, 1884.

The investigations by my track indicator showed on all of the lines that the rails had taken definite forms in the track, which I classified under three distinct types: First, second, and third forms of permanent set.

First form: Rails which were low at the joints and high in the center.

Second form: Rails low in the joints and center, but high in the quarters.

Third form: Rails more or less wavy on the surface, due to conditions of manufacture.

There were combinations of the first and second, and the second and third upon a few rails.

The forms of permanent set also indicated that the rails were not sufficiently stiff so the track could be maintained in good condition for any length of time without constant attention to surfacing by the trackmen, and the results of their labor did not become cumulative from year to year. The rails began to take a set after one or two years cutting out at the joints under the passing wheel loads, the unit fiber strains being higher than in the present stiffer sections. It was evident that the section should have sufficient metal for its elasticity to carry the wheel loads before the permanent set occurred.

I designed the pioneer 5-inch, 80-pound steel rail for the New York Central in 1883 (Fig. 6), to furnish the superintendents of motive power and the engineers of maintenance of way a better steel rail section as an engineering structure than ever before used. It was, as a girder, 66 per cent stiffer than the 4½-inch, 65-pound section of the New York Central & Hudson River Railroad, secured by the addition of only 15 pounds or 23 per cent more metal per yard, and an increase of ½ inch in height for the section. The rail was rolled in April, 1884, and laid in July of the same year, on the four tracks from Grand Central Station to Harlem Junction, 5½ miles. The demonstration of its value in stiffness was a satisfaction to railway officials, and soon was followed by a 5-inch, 80-pound section for the Michigan Central Railway, and a 5-inch, 85-pound section for the Pennsylvania Railroad. The value of stiffness in rails as girders was so obvious that in 1883, after I had designed the 5-inch 80-pound section already mentioned, and before it was rolled, I stated, upon the Boston & Albany diagrams for the year 1883, that it would be possible for them with new stiff rails on a well ballasted roadbed to reduce the undulations of the track to between the fifteenth and sixteenth line upon my condensed diagrams.

I distributed the area of metal for the head, web, and base of the Boston & Albany 95-pound section, which was limited to 5 1/32 inches in height by the railway company owing to the curvature and heavy gradients of the line. I commenced to roll the rail in 1891, and the entire line of 200 miles of double track from Boston to Albany was completed in the summer of 1897. My inspection of the track in the autumn showed the average undulation for the entire track was 15 42/100 lines per mile upon my condensed diagrams, and confirmed the estimate of 1883, fourteen years in advance of its consummation.

(To be concluded.)

Deep Sea Soundings

The methods of taking deep sea soundings heretofore employed have involved a number of sources of error, the principal one being the form assumed under water by the line, which is calculated to cause an error of at least one thirtieth of the indicated depth, under the most favorable conditions. To eliminate this error completely A. Berget describes in *Comptes Rendus* a piezometer which he has constructed. Water is adopted for the compressible fluid, since its compressibility is practically constant and its sensitiveness uniform at all depths. The instrument consists of a reservoir filled with water, whose base terminates in a long tube of ½ millimeter internal diameter which communicates with a side vessel full of mercury and open for reception of the pressure. The tube is silvered internally and graduated externally. The whole apparatus is 25 centimeters long. As the apparatus descends, the mercury is forced up the small tube and dissolves away the silver, thereby denoting the amount of compression, and hence the depth attained. The apparatus was first graduated experimentally by means of a hydraulic press. A thermometer is attached to the side of the piezometer to allow a correction for thermal dilatation. The sensitiveness of the apparatus may be increased to any extent by enlarging the volume of the water reservoir, and diminishing the cross-section of the graduated tube.

Measuring Shocks of Vehicles and Vibrations of Buildings*

A Means for Investigating Important Traffic Problems

THE traffic problem in great cities is continually growing more difficult. It is necessary to take into consideration the conflicting interests of the vehicles, the highways, and the owners of abutting buildings which are affected by the character of the traffic and the condition of the pavement.

In Paris the difficulty is greatly increased by the nature of the soil, which is undermined by subways, sewers, and catacombs. When we consider the ever-increasing number and weight of automobile vans and trucks, it is not surprising that the vibrations of buildings have become serious enough to justify complaints on the part of their occupants.

When this conflict of interests leads to lawsuits it becomes necessary to determine precisely the nature of the vibrations caused, or sustained, by each of the three elements: the vehicle, the roadway, and the abutting building. For this purpose M. Auclair and I have devised an instrument, the "accelerometer," by which the shocks sustained can be measured.

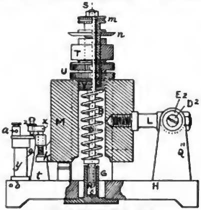


Fig. 2.—Vertical section of accelerometer.

Other things being equal, the wear or fatigue at any point of a rotating body increases with the rate of variation of velocity at that point. It is this change of velocity, or acceleration, that our instrument is designed to measure.

When the tractive effort applied to a vehicle is suddenly augmented the speed of the vehicle is suddenly increased, by an amount which we will denote by A, and which impresses on any mass M, within the vehicle, a force $M \times A$, which tends to displace that mass in the direction opposite to that of the vehicle's motion. It is this force that compels a standing subway passenger to exert a violent effort to maintain his erect posture when the train starts or stops, and it is precisely the same force that tends to separate the bricks of a building shaken by the passage of a heavy vehicle.

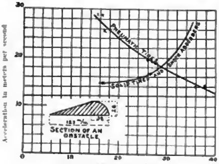


Fig. 5.—Vertical accelerations, plotted as functions of the speed.

As this destructive force is due to acceleration, the magnitude of the acceleration is the quantity to be determined. Our accelerometer (Fig. 1) furnishes an accurate measure of the acceleration at the point where the instrument is placed. This acceleration, as we shall see, is the measure of the fatigue of the material at that point.

The essential parts of the apparatus are shown in Figs. 2 and 3. L is a T-shaped piece of steel, the shank of which is screwed into the side of a bronze cylinder M, weighing about four pounds, and which can turn about the axis of its branches, i. e., the horizontal axis $D_1 D_2$. The bearings are furnished by two pointed screws, $D_1 p_1$ and $D_2 p_2$, which pass through bronze posts $Q\,Q''$, bolted to the base H. These screws are regulated

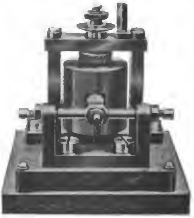


Fig. 1.—The accelerometer of Boyer-Guillon and Auclair.

by means of the nuts $E_1 E_2$. The heavy cylinder M is supported by the spring R which passes through it and is attached at V to the screw bolt U. The lower end of the spring rests on a disk attached to its guide-rod S, which is prevented from turning by the pin N', which passes through the rod and its socket G. The tension of the spring R, which tends to lift the cylinder M and press it against the cross-piece T, is regulated and measured by means of the screw m, the millimeter scale q and the graduated circle of hundredths n, attached to

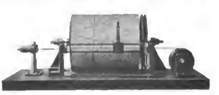


Fig. 4.—The flexion recorder.

the screw. The travel of the cylinder M is regulated by another screw and nut, which comprise the piece U.

The apparatus is completed by an electric contact breaker which indicates the exact moment when the compression of the spring corresponds to the acceleration that is being measured. This condition is satisfied at the instant of making or breaking the circuit. The contact breaker comprises a binding post a, mounted on an insulating support y, and a non-insulated moving piece $z\,x\,t$. The stem of this piece, $x\,t$, passes with slight friction through the support o, and is drawn downward by a spring. The contact is regulated with

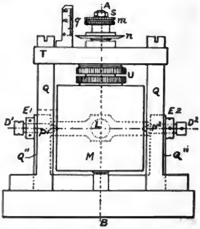
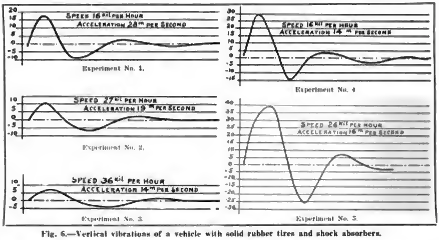


Fig. 3.—Elevation of accelerometer in a plane at right angles with that of Fig. 2.

precision by means of the platinum-pointed screw v, and its nut z. The contact-breaker is actuated by the piece k, attached to the cylinder M. The contact is broken when the cylinder strikes its stop T, and broken when the cylinder separates from the stop. The making or breaking of the circuit is indicated by a telephone, or recorded by a relay.

The measurement of acceleration is made by putting the telephone to the ear and regulating the tension of the spring R, by means of the screw $m\,n$, until the clicking sound ceases. The value of the acceleration at this instant is obtained by a simple calculation from the readings of the scale q and the graduated circle n.



Experiment No. 1.

Experiment No. 2.

Experiment No. 3.

Experiment No. 4

Experiment No. 5.

Fig. 6.—Vertical vibrations of a vehicle with solid rubber tires and shock absorbers.

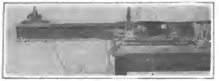


Fig. 7.—The accelerometer connected with an electro-magnetic recorder.

This apparatus affords a means of measuring, so to speak, the degree of comfort that any vehicle offers to its passengers. It can be placed in any part of the vehicle in order to determine the accelerations that are produced at that point, and it is not too large or too heavy to be carried by a tramway, omnibus, or subway passenger.

In a heavy tramway car propelled by compressed air the instrument indicated vertical accelerations ranging from 2 to 4 meters per second, according to the condition of the track. Hence, as the acceleration of gravity

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*By A. Boyer-Guillon in *La Science et la Vie*.

is about 10 meters per second, the apparent weight of a person or object in the car was increased or diminished by two tenths to four tenths its amount while the indicated accelerations were operative.

On the Metropolitan underground line No. 2, in an old first-class car with four wheels, the vertical accelerations attained 0.2 *g* (*g* denoting the acceleration of gravity) on tangents, 0.6 *g* on curves, and 0.8 *g* in braking. In the new cars mounted on two four-wheeled trucks the vertical accelerations are much smaller, ranging from 0.1 *g* to 0.28 *g*. The most violent and disagreeable shocks are produced when the brakes are applied on coming to a curve. There are two reasons for this: the brakes paralyze the springs, and the track is in bad condition owing to frequent braking at the same point.

On the floor of an automobile cab going 17 miles per hour on concrete pavement the vertical acceleration may attain 0.65 *g*. Hence, a person of 150 pounds weight, sitting on the floor of the cab, would be alternately pushed downward and pulled upward with a force of nearly 100 pounds, which would certainly be very disagreeable. In practice these shocks are greatly mitigated by the elastic cushion on which the passenger sits, but these vehicles are far from comfortable.

In a horse-drawn cab (Victoria) with solid rubber tires going 9½ miles per hour on macadam and concrete, vertical accelerations of 0.2 *g* and 0.3 *g* were detected.

Automobile omnibuses showed maximum vertical accelerations of 0.41 *g* on good macadam, 0.32 *g* to 0.84 *g* on wood, and 0.66 *g* to 0.82 *g* on concrete, at a speed of 12½ miles per hour. On very bad concrete pavement accelerations equal to 1 *g* were measured with a speed of only 7½ miles. The starting of the motor, while the vehicle was still at rest, produced a vertical acceleration of 0.14 *g*.

Various tires, suspensions, and shock-absorbers can be compared by placing the accelerometer on a vehicle which is equipped with each of these devices in succession and is moved over the same road, in which obstacles have been placed at regular intervals. In this case it is more convenient to keep the vehicle at rest and to represent the road by two cylinders, about six feet in diameter, rotating beneath its wheels.

This comparative study may be completed by making a graphical record of the displacements of the chassis with respect to the axles. Such a record is easily obtained by means of the flexion recorder shown in Fig. 4. In this apparatus a cylinder covered with paper rotates in contact with a pencil which is impelled in one direction by a wire attached to the bearing of the driving axle and in the opposite direction by a spring. The apparatus is placed on the floor of the vehicle.

The following table gives the results of a series of experiments in which the same vehicle was equipped, first with pneumatic tires, then with solid rubber tires and shock-absorbers. (In this table and in Fig. 5, the unit of acceleration is 1 meter-per-second-per-second = 0.1 *g* nearly.)

	Pneumatic Tires			Solid Tires and Shock Absorbers		
Number of the Experiment	1	2	3	4	5	6
Speed in kilometers per hour	18	27	36	16	26	34
Obstacles met per minute	43	73	102	43	74	..
Maximum vertical acceleration of chassis after passing an obstacle	28	19	14	14	18	25
Deflection of springs, millimeters	17	10	7	30	40	...

The accelerations are plotted, as a function of the speed, in Fig. 5, which shows that pneumatic tires are inferior at speeds below 30 kilometers (about eighteen miles) per hour, but greatly superior at higher speeds, to solid tires with shock-absorbers. Fig. 5 also shows a profile of the obstacles used. The tracings made by the flexion recorder in five of the experiments are reproduced in Fig. 6. In experiment six the wire broke. The maximum ordinates of these curves represent the deflections given in the table above. The curves show that, in regard to the *amplitude* of the "jolt," pneumatic tires are superior at *all* speeds to solid tires and shock-absorbers.

The vibrations and accelerations produced in buildings by the passage of heavy vehicles are divided into three classes—dangerous, tolerable, and negligible—by a commission which the Automobile Club of France and the Central Society of Architects have jointly selected for the study of this subject. When this scale of vibrations has been fixed it will merely be necessary to place in the building under investigation three accelerometers adjusted to read dangerous, tolerable, and negligible accerations, respectively. The record may be made on a rotating cylinder coated with lamp-black, by a stylus moved by an electromagnet connected with the accelerometer (Fig. 7).

In conclusion, we give a few measurements of acceleration made on the ground or floor near motors. On a Seine passenger boat we have measured accelerations of 0.07 *g*, corresponding to vibrations 1/12th inch in amplitude. The reversal of the engines may cause an acceleration of 0.15 *g*. Accelerations of 0.07 *g* were noted in some stations of the Paris subway and the meeting of two autobuses produced an acceleration of 0.14 *g* on a Paris bridge.

In the frames of some machines we have found accelerations exceeding 1 *g*. In these conditions, any object placed on the frame will be lifted by a force greater than its own weight. It is for this reason that objects crawl off the tables and fall to the floor, in workshops and factories.

Prehistoric Man and His Early Efforts to Combat Disease[*]

Some Interesting Experiments Reproducing Primitive Surgical Methods

By T. Wilson Parry, M.A., M.D.

THE Stone Age must be regarded merely as a stage of culture, as every nation and people on their emerging from an animal to a human level, however low, starts with its "Stone" Age, passes through its "Copper" or "Bronze" Age, thence through its "Early-Iron" Age, till it eventually arrives at its Historic period. The anthropological world is indebted to the late distinguished antiquarian, Lord Avebury, for suggesting the division of the great Stone Age into two parts—namely, the Palæolithic or Old Stone Age and the Neolithic or New Stone Age.

Palæolithic man was a hunter living at first on the banks of rivers ("river-drift man" he was then called); then he took to dwelling in caves (cave man). We find him in this last capacity as an artist, showing much ability and even some genius.

Neolithic man was of a different type. I think he may best be described as a farmer, a builder, and a surgeon. The Neolithic period is divided into three parts: (1) the Campigny period, (2) the Robenhausen period, and (3) the Carnac period. It is this last period that will specially interest us now, as we have absolute and certain proof that during this period the surgical operation of trephining was performed.

PRE-PALÆOLITHIC MAN.

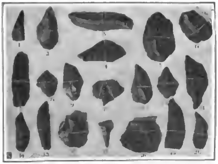
To begin at anything like a beginning we must hark back to times much more remote than these. In prepalæolithic days man was little above the lower animals. The picture that I have of the earliest primitive man at present is an admixture of Pithecanthropus erectus and the Piltdown lady. With the former's cranial capacity of 850 cubic centimeters and the latter's simian lower maxilla and canine tooth, we are getting dangerously near our cousins the anthropoid apes. A large male gorilla may have a capacity of 600 cubic centimeters, and there would therefore be much less distance between him and "the fossil man of Java" than exists between this latter and an average modern European cranium. I need not enter into the controversy as to whether these fossilized human crania belong to the early Pleistocene or late Pliocene period. The geologist has strong inclinations toward the former, while the anthropologist has much to say on the latter. I have faith that there are still to be unearthed anatomical surprises of unparalleled importance which when discovered will necessitate a constant rearrangement of ideas as fresh material is brought to light.

ANIMALS' SELF-CURATIVE INSTINCTS.

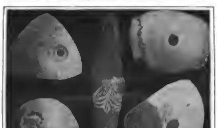
It is well known that animals possess strong self-curative instincts. Dogs and cats when indisposed will eat grasses that have a medicinal action, usually of an emetic or purgative nature. The fibrous-rooted wheat-grass,[1] *Triticum caninum*, is frequently eaten by the former. If an animal has been injured it is noticed continually to lick the affected part, which is a somewhat crude combination of our modern fomentation and massage. Prehistoric man would most certainly have licked his wounds. Later, when he had lost some of his earliest animal instincts, he would observe what animals did and imitate them. Thus the use of hellebore[2] was believed to have been discovered from the goat.[3] Virgil tells us that dittany was "eaten by wild goats when they were shot with darts."[4] Pliny tells us that bleeding was taught man by the hippopotamus, "that intelligent animal finding himself plethoric, goes out on the banks of the Nile and there searches about for a sharp-pointed reed, which he runs into a vein in his leg, and having thus got rid of a sufficient amount of blood closes the wound with clay." Buffaloes, horses and camels are exceedingly fond of licking salt. Przevalsky says: "On the Mongolian camels salt, in whatever form, acts as an aperient, especially if they have been long without it." Livingstone says that "the chimpanzee, soko, or other anthropoid apes will staunch bleeding wounds by means of their finger or of leaves, turf, or grass stuffed into them." Primitive man must have done likewise, only always a little more.

THE INSTINCTIVE PERIOD OF MEDICINE.

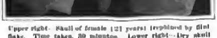
The first period in the history of medicine is known as the Instinctive Period or the Period of Demonology. As embryology epitomizes evolution, so the study of the present-day primitive savage unfolds to us the larger history of prehistoric man. It was no doubt the twin mystery of disease and death that first stimulated man to think, that is why the medicine-man and the priest were one and the same individual at the outset. The position of the medicine-man in the tribe must have been a most exalted one. In a fascinating book just published on the American Indian, called "The Vanishing Race,"[5] this is well shown. "The Indian," it says, "aspires to be a great hunter, he seeks fame as a noble warrior; he struggles for the eagle feathers of distinction, but his greatest longing is to become a medicine-man and know the great mystery." Witchcraft and magic early took a chief part in the treatment of disease, and demonology reigned supreme for many millenniums. Demonology is based on "Animism," and this latter briefly consists in the belief in the influence of the spirits of dead persons. Animism has its beautiful as well as its hideous aspect. The wide belief among savage races that inanimate objects, as well as animate beings, are all possessed of a



Selected Neolithic flint flakes and borers (Coleraine). No. 20 was used in trephining skulls (Figs. 3 and 4).



Upper right—Skull of female (21 years) trephined by flint flake. Time taken, 30 minutes. Lower right—Dry skull partially trephined by shark's tooth. Time taken, 1½ hours. Lower left—Skull of male (44 years) trephined by obsidian knife (Admiralty Islands). Time taken, 30 minutes. Knife used shown in center. Upper left—Skull of infant (18 months) trephined by flint flake. Time taken, 15 minutes.



Hafted shark's tooth.

Illustrations representing experiments of different kinds of primitive trephining, with tools used.

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[*] An abstract of a presidential address delivered before the North London Medical and Chirurgical Society, and published in *The Lancet*.

spirit has been well demonstrated by Maeterlinck's excellent allegory "The Blue Bird," which shows the happy side of this creed. The unhappy side is illustrated by the reverence bestowed on spiritual monsters and the propitiation required by them. The three chief theories of disease were: (1) the anger of a disaffected spirit, (2) witchcraft, or (3) offended spirits of dead persons. The Manitra,[3] a low race of the Malay Peninsula, believe that there is a separate disease-spirit for every illness, one for smallpox, one for inflammation of the hands and feet, and one for hæmorrhage; in the last-named case the spirit is thought to fasten itself on the wound of the individual and suck out his blood. The aboriginal New Zealanders[4] had a separate demon for each part of the body to cause disease: Tonga caused headache and sickness; Moko-Tiki was responsible for chest pains, and so on. In Brittany to-day similar pagan ideas are universally accepted, but under different auspices. The Breton's deities are neither Tonga nor Moko-Tiki, but if the Bretons are suffering from boils they offer prayers to St. Maudez; if from fevers they petition St. Gionery.[7] The earth from the tomb of this latter saint is considered a cure for any kind of fever. It is sold in little muslin bags and tied round the necks of the patients.

DEMONOLOGY THE REASON FOR TREPHINING.

It must have been but a short step for the first man, who, firmly believing in demoniacal possession and who, at the same time, suffered either from frequent fits, severe pain in the head of a periodic or paroxysmal nature, chronic hemicrania or unbearable Ménière's disease, to make an effort to free himself from his fetters. Life had become an intolerable burden to him, and he believed there was a devil inside his cranium that was petitioning somewhat persistently for liberty. The first operation must have been troublesome and tedious, not to mention its extreme danger. The medicine-man had to incise the scalp with a sharp piece of flint, arrest the bleeding, and scrape the bone. This would take many hours to perform, but the patient was helpful and anxious to get rid of his devil, and possessed that unflinching stoicism to pain that is characteristic of the savage. If the patient recovered, he was reverenced as a hero. If he died his skull was eagerly sought after. The trephined portion was removed by flint saws and pieces of bone, edged by part of the healed cicatrix, were removed. Either a hole was passed through this or a groove made for affixing a cord, so that it might be worn as an amulet to defend the wearer against the disease from which the dead man suffered. The first skull of this kind to which the attention of scientists was drawn was discovered by M. Prunières in the year 1868 in a dolmen near Aiguières. This observer mistook the hole with the smooth edges for an opening that had been made artificially after death for the lips, in the conversion of the skull into a drinking cup, a custom well recognized among savage tribes. It was left to Prof. Broca to interpret this, and he showed indubitably that the hole in the skull had been made during life and had been done by scraping.[8]

NEOLITHIC TREPHINING IN GREAT BRITAIN.

It might have been thought, considering the number of trephined skulls that have been unearthed in France, that the custom would have spread to the British Isles, as only the Channel separated the two countries, and we have evidence that no inconsiderable amount of traffic existed between the shores in Neolithic times. I have only been able to hear of three such skulls that have been discovered in this country, and would be most happy to be informed of any other specimens should they exist. The three specimens of which I know are the following: 1. A skull that was dredged from the bottom of the docks at Port Talbot, South Wales, in or about 1870-72. I have a photograph of this skull, which has been kindly lent to me by Mr. Thomas Gray. This skull shows a frontal excavation over the right supraorbital region. 2. An interesting specimen showing a ring-trephine, as if an effort had been made to remove a rondel of bone.[9] This specimen was excavated in the autumn of 1863 from a long barrow, near Bisley, by the late Dr. W. H. Paine, assisted by Dr. Henry Bird. I have to thank Mr. A. E. W. Paine, son of the first-mentioned excavator, for kindly furnishing me with a photograph. Prof. Arthur Keith, who has seen this specimen, states that "there is no mark of inflammation or disease on the bone." This probably belongs to the Bronze Age. 3. The third specimen is in the Northampton Museum. I can emphatically state that the three trephine holes in the form of a triangle, on the vertex of this skull, were not made during the Stone Age nor by any Stone-Age implements. All that is known of this specimen is that it was found "outside the British Camp called Hunsbery" in Northampton. On a modern skull I have made as exact a model as I can of the three holes, as regards size and relative position, and it is my opinion that they were made on the original not from any demonological reason, but as a means for suspending the skull as a trophy by a Bronze Age or later headsman. I have to thank Mr. Thomas J. George, curator of the Northampton Museum, for his kindness in sending me tracings[9] of General Pitt-Rivers's plates of this skull. It is probable that only one of these three specimens alluded to above is Neolithic.

MELANESIAN TREPHINED SKULLS.

In the Museum of the Royal College of Surgeons of England are six skulls of modern Melanesians that have been either partially or wholly trephined by natives of those islands. In three of these specimens a complete perforation has been made in the cranial bones, and in the remaining three either the outer table alone or the outer table and diploë have been removed. One, a male from New Britain, has a large hole measuring 28 millimeters by 34 millimeters in the right occipito-parietal region. The outer edge of this hole is thin, beveled and smooth, and shows a healed surface, demonstrating a successful operation. Of the five other skulls, all of which came from New Ireland, one shows two frontal scrapings. On the left side the outer table has been completely rubbed through and on the right is a circular scraping leaving a boss of bone in the center, which looks as if an attempt had been made to remove a small rondel of bone. In the third skull is a beautifully rounded perforation measuring 14 millimeters by 15 millimeters in the left frontal region. The edges of this hole show perfect healing. There is a diseased patch of bone with considerable erosion in the mid- and right-frontal region which demonstrates the obvious reason for this operation. The fourth skull is similar to the last in the fact that a large scraping (17 millimeters by 28 millimeters) has been made, probably as a direct counter-irritation to relieve severe or continuous headache, in front of an extensively diseased area of bone. In the fifth skull there is a large elliptical scraping, 48 millimeters by 35 millimeters, in the right parietal region. A deep furrow in the center of this scraping illustrates the method by which this was done. In the sixth and last specimen there is a large perforation, 23 millimeters by 40 millimeters, over the left frontal region, and part of this hole is filled up with fresh callus formed during the process of healing. All the cases have undoubtedly been done by scraping the bone with obsidian flakes. In Melanesia after the operation has been performed the scalp is replaced and simply bound into position by a bandage made of banana fibre. My thanks are due to Prof. Keith for his courtesy in permitting me to describe these specimens in this paper.

NEOLITHIC METHODS OF TREPHINING.

Being anxious to ascertain how Neolithic man trephined living subjects with the crude materials at his disposal, I made a series of some 19 experiments both upon recent and dry skulls. (See illustrations.) When showing the results of some of these experiments to Prof. Keith he informed me of a pamphlet by the late Dr. Lucas-Championnière[10] in which I would find that several of my experiments had already been done by him. I was quite unaware of this brochure when making my tests. Referring to this pamphlet it appeared to me that Dr. Lucas-Championnière had only experimented with flint. The materials I used besides flint were obsidian, shark's teeth, shell, and slate. Flint I used both in the form of Neolithic scrapers and as a hafted sharp point to a bow-drill. This bow-drill, I may mention, is one of the oldest forms of mechanical contrivance. Obsidian I also used in two ways—first as an ordinary flaked scraper, and secondly as a hafted implement in the form of an Admiralty Island knife. I used two kinds of shark's teeth—a small variety, for an infant's skull, was obtained from the King's Mill Islands, and was identified by Mr. C. Tate Regan, of the Natural History Museum, as belonging to "*Carcharias glaucus* or a related species," while the larger specimen, which I used for adult skulls, was *Galeocerdo arcticus*. The shells I used were beach-worn specimens of *Ostrea edulis*.

For scraping a hole in bone, metal not being considered, there can be no better natural implement than a well-flaked piece of flint. When flint cannot be obtained, as in volcanic regions like the South Pacific Islands, obsidian makes a good substitute. Obsidian is a natural volcanic glass and can be flaked, in the same way as flint, by a sharp well-directed blow. Contrasting these two substances I would give flint the first place. A hard, sharp edge can be obtained in flint which is more resistant to counter-pressure than is obsidian. Both flint and obsidian when freshly flaked are excellent substances for surgical purposes by virtue of their smooth surfaces, which would be aseptic. The method I employed for scraping the trephine-hole with flint and obsidian was the following. With a suitable flake I scraped as nearly as possible along a single line. This line I gradually converted into a groove, which soon showed two more or less prominent ridges. With a curved movement of the scraper I next attacked these edges until a depression had been produced in the bone which gradually assumed an elliptical shape. It was now only a question of time and manipulation to convert this elliptical depression into a circular one, and thence, having penetrated the inner table of the skull, to expose the dura mater and enlarge the foramen to the size and shape required. As regards the bow-drill I bored a succession of holes, some fifteen in number, in a circular manner on the site chosen. These I enlarged till they touched one another. The next step was to break down the edges between them with a sharp, strong flake, and then by means of sawing and scraping eventually to remove a complete rondel of bone. This is an extremely tedious and clumsy operation, and not in any way calculated to bear comparison with the simpler method of scraping. As regards sharks' teeth as surgical instruments, I am satisfied that there is no more excellent natural implement for boring holes in bone than a hafted shark's tooth. Its keenly serrated edges and its strong, sharp point make it an instrument invaluable to the primitive surgeon. It moreover possesses a natural flange which converts it into a trephine of undeniable utility, for the flange is so placed as to prevent the point penetrating too deeply to the wounding of the dura mater. A ring of holes (as in the case of the bow-drill), packed as closely as possible, followed by breaking down the bridges between them, makes a hole (after removal of the rondel) as clean and neat as the most fastidious chirurgeon could wish. Trephining by shell was probably never attempted by Neolithic man in Europe, though primitive man in the South Pacific Islands certainly used shell for this purpose, and shell knives and lancets for opening abscesses. It took me nearly 25 minutes to trephine the skull of a 9 months old infant, which in time bears most unfavorably with the same operation on a 14 months old child which only took 9½ minutes, or on a 16 months old child, which took 15 minutes. I used slate in one instance, but it took me nearly 60 minutes to make a small hole in the skull of a man of 44 years. The originals of my experiments are exhibited in the Historical Medical Museum, and I have to thank the curator, Mr. C. J. S. Thompson, for his kind loan of aboriginal trephined skulls.

CONCLUSION.

We have been looking back into the far-away past and have been endeavoring to piece together the history of prehistoric man from specimens of his handiwork that have been heirloomed to us by the sheltering hand of Nature, who has protected them for us either by covering them over with the debris of rock or hiding them under stalagmite or in the deep breccia in the floors of caverns. To this has been added a passing glimpse at the methods of present-day primitive tribes. Tylor says:[11] "The uniformity which so largely pervades civilization may be ascribed, in great measure, to the uniform action of uniform causes." Thus it is that the combination of these two parallel studies enables us to get a true insight into the life of prehistoric days.

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The Use of Marine Turbines

ALTHOUGH we have read of steam turbines for marine propulsion for a number of years, still the subject is a new one to many people. It may interest these to learn that of the Parsons type there are 12,360,000 horse-power in use at present, and of this enormous amount nearly 2,000,000 horse-power were added during the current year. Of the above power the greater part is used in war ships, and only 1,850,000 is found in commercial vessels. The reason for this is that, although the steam turbine is very economical in itself, when it can be operated at the proper speed in revolutions, this speed is entirely unsuited for the best propeller efficiency, and consequently a compromise had to be made on both sides, with unprofitable results. Another objection to the turbine for use in vessels was the impossibility to properly maneuver them in making landings, etc., so that a combination of reciprocating engines and turbines was occasionally adopted, the regular engines being used exclusively for maneuvering, and for backing, which ordinarily requires an entirely separate turbine; but this was obviously a makeshift, and an undesirable complication that did not meet with great favor. All this has now evidently been changed by the invention of reducing gears that will permit the turbine to be run at an economical speed, while the propellers are operated at their most efficient rate of revolutions, making a power plant that is more economical and compact than the popular reciprocating engines. These reducing gears also make it possible to maneuver with the turbine. So far there are four systems for gearing down the propeller speed: the regular gear wheels of Parsons and Westinghouse, the Fottinger hydraulic transformer and the electric drive, where the steam turbine operates a dynamo, which furnishes current to a motor attached to the propeller shaft. The latter system is said to be very promising, as the loss of power in the transformation is very small, and the speed and direction of the vessel can be regulated and altered very easily and quickly.

One of the Mysteries of Chemistry

Useful Reactions Where the Inducing Substance is not Changed or Consumed

There are a number of chemical reactions that are collectively known as catalysis, about which very little is as yet definitely known, although in a few of the known cases of seemingly catalytic action certain intermediate reactions have been determined that apparently explain these particular processes; but whether similar processes take place in all cases is by no means certain. In its broad application the term catalysis is applied to processes that are induced by the presence of substances that are apparently inactive, and take no part in the reactions, which may be either accelerated or retarded by the same. An example of catalysis is that of hydrogen peroxide which, in dilute solutions, decomposes but slowly into water and oxygen. If a small quantity of platinum black is added the decomposition becomes so rapid as to show considerable effervescence. This action is continuous as long as any of the original liquid remains, and there is no wasting or consumption of the platinum black, all of which can be subsequently recovered unchanged by filtration.

Catalytic reactions occur in all branches of chemistry, very many being known, and the catalysts occur in both solid, liquid and gaseous forms, although the most numerous class are solids.

In a recent lecture at King's College, London, Prof. P. Sabatier considered the subject of catalysis, and gave many examples of this intricate action, together with such explanation of the theories of the process as are available; and from this lecture the following abstracts are derived:

THEORIES OF CATALYSIS.

Berzelius, who first called attention to the phenomenon, offered no real explanation, but suggested that catalysis was due to a change in the polarity of the atoms concerned. The importance of a fine state of division of the catalyst has suggested a physical explanation, long unchallenged. According to this theory, when platinum black is introduced into a mixture of oxygen and a combustible gas (hydrogen, alcohol vapor, etc.), the gases are absorbed rapidly by the porous material which attracts them to its surface, and the gases thus absorbed are subject to increased pressure and a local rise of temperature, both of which conditions assist the chemical interaction of the gases. The products are immediately removed, and replaced by a fresh quantity of the original gases, and so the reaction continues. The heat, set free by compression and by the combination of the gases, accelerates the action, and the platinum may even become incandescent. The function of the catalyst is thus to produce a local increase of pressure and temperature, so as to render possible, apparently at ordinary temperatures, a reaction which normally occurs only at higher temperatures. Ostwald regards the catalyst simply as the accelerator of a possible reaction which would, without the catalyst, take place slowly, and sometimes so slowly as to be incapable of detection. This theory does not offer an explanation as to the attraction of certain gases and not others by the surface of the catalyst; thus, platinum black must be supposed to attract hydrogen and oxygen, but not aqueous vapor. Further, certain catalytic actions are effected by platinum foil or wire, as well as by platinum black. A platinum spiral, heated to expel gases from its surface, and held over methyl alcohol, causes oxidation of the vapor to formaldehyde, the heat generated keeping the metal incandescent. A large sheet of platinum foil, slightly heated and held above an unlighted Bunsen burner causes combination of the gas and air; the foil becomes incandescent and may start a flame. In these cases, the porous solid is not present. Moreover, in the physical conception of catalysis the important differences in the effects of various solid catalysts having the same structure and state of division, are ignored. Zinc oxide and titanic oxide are physically similar but act very differently on formic acid vapor at 300 degs. Cent. With zinc oxide, equal volumes of carbon dioxide and hydrogen are formed, while with titanic oxide, water and carbon monoxide alone are produced. The physical explanation of catalysis is not applicable to liquid and gaseous catalysts which form a homogeneous mixture with the reacting substances. A rational theory of catalysis must be based on the chemical action of the catalyst which can unite with some of the reacting substances to form an unstable intermediate compound.

Two chemical systems, which are themselves stable though capable of undergoing change, such as hydrogen peroxide, and chromic acid solution mixed with sulphuric acid, will, when mixed, act catalytically one on the other, constituting reciprocal catalysis, the two changes taking place simultaneously in identical proportions. The hydrogen peroxide and chromic acid are both decomposed and the same quantity of oxygen is generated from each. This indicates that the cause of the decomposition is the formation of an unstable compound of 3 molecules H_2O_2 and 2 molecules CrO_6H_2. This compound is decomposed as quickly as it is formed, into free oxygen, water and chromium sesquioxide which dissolves in the sulphuric acid. This intermediate compound can be isolated by suitable means. When dilute solutions are used, instead of oxygen being evolved, a blue liquid is produced. The blue substance can be extracted with ether, and isolated by evaporating at —20 degs. Cent. At the ordinary temperature this substance decomposes into oxygen, water, and chromium sesquioxide. A similar example is the interaction of hydrogen peroxide and potassium permanganate, and the existence of an intermediate unstable compound must be assumed in this case also.

ORDINARY CATALYSIS.

By analogy, it may be concluded that the catalyst combines rapidly with one of the substances present, and the compound formed reacts quickly with the other substances, setting free the catalyst which can act again in the same manner indefinitely. The intermediate compounds can sometimes be readily detected, when they are stable at some other temperature than that of the catalytic reaction. This is the case in the production of ether or of ethylene from alcohol by means of sulphuric acid. Concentrated sulphuric acid combines with alcohol to form ethyl-sulphuric acid:—

$$C_2H_5.OH+SO_4H_2=SO_4H.C_2H_5+H_2O.$$

If the liquid be kept cold, no further change occurs. On heating to 60 degs. Cent. in the presence of an excess of alcohol, the latter reacts on the ethyl-sulphuric acid to give ether, which distils off, and sulphuric acid which again combines with alcohol:—

$$C_2H_5.OH+SO_4H.C_2H_5=(C_2H_5)_2O+SO_4H_2,$$

the sulphuric acid thus acting as catalyst in the reaction:—

$$2(C_2H_5.OH)=H_2O+(C_2H_5)_2O.$$

A small quantity of acid can in this way transform a large quantity of alcohol into ether. If the liquid is quickly heated to over 150 degs. Cent., the reaction is different. The ethyl-sulphuric acid is decomposed with formation of ethylene and sulphuric acid:—

$$SO_4H.C_2H_5=C_2H_4+SO_4H_2.$$

The acid thus formed acts again in the same way, serving as catalyst in the reaction:—

$$C_2H_5.OH=C_2H_4+H_2O.$$

The intermediate compound in both of these reactions is easily detected, since it is stable at a lower temperature. Another example is furnished by Squibb's method for the production of acetone. The vapors of acetic acid are passed over calcium carbonate at 500 degs. Cent. The initial reaction is evidently the formation of acetate:—

$$CaCO_3+2(CH_3CO_2H)=CO_2+H_2O+(CH_3CO_2)_2Ca.$$

Below 400 degs. Cent., the reaction produces calcium acetate which is stable at the temperature, but at 500 degs. Cent. the acetate is decomposed into acetone and calcium carbonate:—

$$(CH_3CO_2)_2Ca=CaCO_3+CH_3CO.CH_3,$$

and a small quantity of calcium carbonate can thus change any quantity of acetate acid into acetone. In both these examples, it is impossible to overlook the intermediate compound which serves as a step in the reaction. But usually the intermediate compound cannot be detected with certainty because it is not sufficiently stable at any temperature to be isolated. This is the case in most of the catalytic reactions induced by platinum or finely divided metals. But some idea of what occurs can be formed by analogy. Platinum black, when introduced into a mixture of alcohol vapor and air, fixes oxygen on its surface in the form of a true chemical compound, such at PtO, and the oxide reacts immediately with the alcohol vapor to form aldehyde, the platinum being set free and acting again in the same way indefinitely. Similarly, reduced nickel placed in a mixture of hydrogen and benzene vapor, fixes hydrogen on its surface in the form of a thin layer of an unstable hydride, such as NiH_2. At a suitable temperature, about 180 degs. Cent., this hydride reacts immediately with the benzene vapor, forming cyclohexane, and the nickel is regenerated and acts again in the same way.

It also frequently happens that the unstable intermediate compounds formed by the catalysts can determine the reaction in either direction. Thus, platinum black absorbs free oxygen and yields it again immediately to oxidizable substances, but it can also, by virtue of the same affinity, take oxygen from substances capable of readily losing it. When platinum black is dropped into hydrogen peroxide, the platinum immediately takes up oxygen, forming the unstable oxide, which decomposes at once. Platinum black thus acts as catalyst in processes involving the addition or the removal of oxygen, according to circumstances. Finely divided copper or nickel placed in an atmosphere of hydrogen, fix the gas temporarily and pass it on to other substances. Conversely, in the presence of substances capable of giving up hydrogen, these metals take up hydrogen, which is immediately set free. Thus aldehydes passed with excess of hydrogen over nickel below 200 degs. Cent. form the corresponding primary alcohols. Conversely, the vapors of the primary alcohols, passed over nickel at 250 degs. Cent. are decomposed into aldehydes and hydrogen. Cases of this kind are very numerous. In conjunction with Mailhe the author has shown that the vapor of phenol when passed over thoria at 450 degs. Cent. loses water and is converted into phenyl ether. Later, the author and Espil showed that a mixture of phenyl ether and water vapor, passed over thoria at 450 degs. Cent. readily forms phenol. The two reactions occurring at the same temperature necessarily do not proceed to completion. A similar inversion of the effect of the catalyst is often met with. The recent researches of Bourquelot have shown that emulsin, a soluble organic catalyst, not only effects hydrolysis of glucosides, but can very often lead to the formation of the same glucosides by dehydration.

The catalyst appears to play an active part in the reactions which it determines. The temporary combination of the catalyst with one of the reacting substances makes the reaction possible, and a small amount of the catalyst can change a large quantity of the reacting substances, because the catalyst is regenerated by the rapid decomposition of the intermediate compound. There is thus no definite relation between the mass or the active surface area of the catalyst and the weight of the substances which it can produce. The reactions will, however, be more rapid as the quantity of catalyst is greater. Their velocity will be, in some degree at least, proportional to the mass of the catalyst in a homogeneous system, or to the surface in the case of solid catalysts which act only at their surface.

This chemical conception of catalysis has led the author with his pupils to the discovery of new facts, which may be grouped under two headings, catalysis (1) by metals and (2) by oxides.

In a series of researches extending over nearly 17 years, in collaboration with Senderens, Mailhe, Murat, and Espil, it has been shown that the common metals iron, copper, cobalt, and especially nickel, in a fine state of division, such as is produced in the reduction of the oxides by hydrogen, carbon monoxide, or alcohol vapor, form active catalysts in processes of adding or withdrawing hydrogen, and in molecular decompositions.

The catalytic action of finely divided platinum had been used chiefly for effecting oxidation. Only in few cases had its power of effecting the addition of hydrogen been recognized. In 1897, the author discovered with Senderens, that in the presence of reduced nickel, free hydrogen at a very low temperature can rapidly change ethylene into ethane, and it has since been shown that this catalytic action of nickel is quite general and is capable of effecting the addition of hydrogen not only in known reactions usually carried out by means of ordinary reducing agents but also in other reactions which could not be effected by the old methods. The method employed by volatile substances is very simple; it is only necessary to pass them together with hydrogen in excess through a column of reduced nickel kept at a suitable temperature. In this way, nitro-compounds can be converted into amines, e. g., nitrobenzene into aniline. Ethylenic and acetylenic compounds are readily converted into saturated compounds. Aliphatic aldehydes and ketones yield the corresponding alcohols, and amines are readily obtained from nitriles, oximes and amides. Carbon monoxide and dioxide are converted into methane, and this may possibly be the basis of an important commercial process for manufacturing from water-gas or coal-gas a lighting gas rich in methane and having a high calorific power. The most valuable application of the new method is the formation of cyclohexane derivatives by the addition of 6 atoms of hydrogen to the benzene nucleus. By simply passing benzene vapor with hydrogen over reduced nickel at 180 degs. Cent., the benzene is completely converted into cyclohexane. In the same way, phenol is converted into cyclohexanol, and analine into cyclohexylamine.

Certain conditions are essential for the success of the process. The temperature must be kept within certain limits, which are wide in some cases, as with nitro- and ethylenic-compounds, but narrow in others. The reduction of benzene cannot be effected above 250 degs. Cent.; at higher temperatures cyclohexane loses hydrogen. The best temperature is usually about 180 degs. Cent. The catalyst should be prepared in the reaction tube itself, by reducing with hydrogen an oxide as free as possible from chloride and sulphate. The oxide obtained by calcining at dark red heat nickel nitrate prepared from commercial nickel and nitric acid is generally used. The nickel is more active the lower the temperature at which it is prepared, and the lighter the oxide from which it is formed. The metal obtained by reducing the green hydroxide below 300 degs. Cent. is exceedingly active and often causes molecular changes in compounds subjected to catalysis. Nickel reduced above 750 degs. Cent. will not convert benzene into cyclohexane, but will change nitrobenzene into aniline. An essential condition is the conservation of the catalyst, the activity of which may be spoiled by impurities in the hydrogen or in the reacting substances. Chlorine, bromine, iodine and sulphur are specially harmful in the case of nickel. In conjunction with Espil, the author has recently shown that the humidity of the hydrogen has no unfavorable effect, and is favorable in certain cases. But while it is useless to dry the gas, it is necessary to purify it thoroughly. It has been supposed that traces of chlorine, bromine, iodine or sulphur would immediately render the nickel inactive, but this is not the case. Benzene containing 0.5 per cent of iodine can be converted into cyclohexane, and during an experiment lasting several hours, 150 cubic centimeters of the solution was treated. On breaking the tube, the first half of the column of nickel was found to have taken up iodine and was inactive, and the second half was unaltered and was capable of containing the reaction. Thus the destruction of the catalyser by iodine took place slowly through successive layers, and in the actual experiment 250 cubic centimeters of cyclohexane could have been obtained before the tube became inactive. A similar result was obtained with benzene containing 10 per cent of carbon bisulphide.

Reduced nickel effects the combination of hydrogen with numerous substances, which need not necessarily be in the gaseous state. When a current of hydrogen is passed through a fatty oil, such as earthnut (arachis) oil at 180 degs. Cent., in which reduced nickel is suspended, the oleic esters are converted into stearic esters and the reaction is completed in a few minutes. The oil changes to a fat, which solidifies on cooling. This conversion of oils into fats is usually accompanied by deodorization. It is now the object of important industrial applications.

The Explosibility of Grain Dusts*

As a result of a number of explosions in grain mills and industrial plants, and more especially as a result of an explosion in a feed-grinding plant at Buffalo, New York, in June, 1913, by which thirty-three men lost their lives and upward of seventy were injured, a co-operative movement between milling interests generally and the Bureau of Mines was arranged for the purpose of making a scientific study of the explosibility of grain dusts, and of methods pertaining to the prevention of such explosions.

In order to make a laboratory study of the problem, samples of the following dusts were collected, and the conditions under which they were produced were studied:

1. Dusts produced during the process of elevating and handling grain, and known as elevator dusts;
2. Wheat-flour dusts from rolls, bolters, purifiers, conveyors, packing machines, etc.;
3. Wheat-flour dusts from beams, rafters, elevator heads, etc.;
4. Dusts produced during the cleaning of oats;
5. Dust from grinding white corn;
6. Dust from grinding yellow corn;
7. Dust from grinding oat hulls;
8. Oatmeal dust from packing machines;
9. Floor dusts from elevator sweeping;
10. Oat-groat dusts after aspirator.

Experiments were then started in the Bureau of Mines, Pittsburgh, to determine the ignition-temperature of these dusts, using the method of Wheeler.[1] This consisted in forcing the dust in a cloud through a glass tube, 3 inches in diameter and 55 inches long, against a heated platinum coil, which was 15.75 inches from one end of the tube. The temperature of the coil was obtained by a Pt-PtRh thermocouple, having its hot junction within the quartz tube upon which the coil was wound. Using this method Wheeler determined the ignition-temperature of many dusts, obtaining results varying from 805 deg. Cent. for sugar, 900 degrees to 1,035 degrees for starch, 980 degrees for oat husks, 985 degrees for grain (flour-mill) to 1,030 degrees for flour and 1,100 deg. Cent. for castor-oil meal. The results obtained upon grain dusts by the author varied from 985 deg. Cent. for oat and corn elevator dusts, 1,015 degrees for feed dust from dust collector, 1,020 degrees for ground oat hulls, 1,025 degrees for yellow-corn dust, to 1,115 degrees for wheat elevator dust and 1,265 degrees to 1,270 degrees for flour dusts. Wheeler worked with samples which had been dried at 107 deg. Cent., while the author used the samples as received from the mill.

While the work gave the relative ignition-temperatures it did not give the lowest temperature of ignition or the relative inflammability. This latter was determined by means of an apparatus developed in the Bureau of Mines. It consists of an explosion flask of about 1,400 cubic centimeters (85-36 cubic inches) capacity having two tubulars, a platinum coil, a device for driving a dust cloud against the coil, and a Crosby pressure-gage for measuring the pressure developed. In each determination 50 milligrammes (0.00176 ounce) of dust is forced in a cloud against the coil, which had been previously heated to a known temperature determined by a thermocouple. The temperature is that inside the coil and therefore higher than the actual temperature on the outside of the coil. The dust is ignited by the heated coil and a pressure developed within the flask, which is registered by the gage. The relative inflammability at any temperature is measured by the difference in the pressures developed within the flask.

Determinations were made of pressures developed by the different dusts, as received and dried at 105 deg. Cent., when they were forced against the coil heated to 1,200 degrees, 1,100 degrees, 1,000 degrees and 900 deg. Cent. As no standard has been taken for carbonaceous dusts, other than coal dust, Pittsburgh standard coal dust, which is very constant in its properties, and which is used as a standard in the Bureau of Mines, was taken as a standard and all determinations run against it and checked against each temperature.

Tables and curves indicate that most, if not all, the grain dusts are more inflammable than Pittsburgh standard coal dust, higher pressures being developed in most cases, and especially so at the lower temperatures. The results also seem to indicate that the dusts from oats and yellow corn are more inflammable than those from wheat or other grain.

It is interesting to note the difference in the inflammability of the dried and undried dusts. In nearly every case the pressure developed was appreciably increased after drying.

Experiments carried out by the Bureau of Mines[2] have shown that an explosion could be produced when there was only 0.032 ounce of coal dust suspended in each cubic foot of air, or one pound in 500 cubic feet of air. Since preliminary experiments indicate that many of the grain dusts have relatively a lower ignition-temperature than many kinds of coal dust, and are relatively more inflammable, it may be possible that an ignition of dust of this nature might be produced with a smaller proportion per cubic foot than is necessary for coal dust.

The following causes have been assigned to many of the explosions in milling plants in this country and abroad:

1. Use of open lights, or naked flames, such as lamps, torches, gas jets, lanterns, candles, matches, etc.
2. Property fires.
3. Introduction of foreign material in grinding machines.
4. Electric sparks from motors, fuses, switches, lighting systems.
5. Static electricity produced by friction of pulleys and belts, grinding machines, etc.

The investigation has indicated that a large number of the recent explosions and fires have been caused by the introduction of foreign material into grinding machines.

It would appear that a possible means of prevention would be to devise some system by which the foreign material might be removed before it reached the mill. Other preventions suggested are: A complete electric-lighting system, the use of portable electric lamps instead of lanterns or naked lights, the inclosing of the electric-light bulbs in strong wire guards or protectors, and the possible use of vapor-proof globes, and the locating of all fuses, switches, starting boxes, motors, etc., at points where no dust is present. It is also advised to have the receiving bins from the grinding machines as small as practical with the operations, as increased size gives increased space for dust clouds and therefore opportunity for a more violent and destructive explosion.

Photo-Activity of the Blood

The interesting observation has been made that the blood of a guinea-pig will produce in from 16 to 13 hours, on a photographic plate a few millimeters distant, the image of a stencil placed in front of it. "It demands further investigation," says *Die Naturwissenschaften* (Berlin), "to decide whether we have here the effect of rays emitted by the blood, or whether it gives off a gas which affects the plate" (Schlaepfer, Zeitschr. f. Biol. 1914).

"Since a very thin leaf of aluminium interposed prevents the effect it cannot be due to alpha, beta, or gamma rays. A layer of unglazed paper (matt papier) makes the image fainter but does not preclude its formation. Since after more than 7 hours of strong illumination a mere trace of the effect of light passing through the paper could be observed, the effect produced by the blood cannot be ascribed to light, for blood is capable of emitting merely a very minimal intensity of light, which would produce no effect on the far side of the unglazed paper.

"On the other hand the paper could easily be penetrated by gas. It can, in fact, be demonstrated that the blood gives off peroxide of hydrogen, as is proved by the turning blue of a piece of filter-paper which has been saturated with a solution of potassium, iodide, starch-paste and ferrosulpate, and then laid over the blood at a distance of 4 millimeters.

"But hydrogen peroxide is capable of attacking photographic plates. The effect is due to the red blood corpuscles only, and not to the serum. Hence it is not a case of photo activity, but of the emission of a gas, whose appearance in the blood was not hitherto known and is of considerable theoretic interest."

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* Notes from a preliminary report by David J. Price and Harold H. Brown, to the Millers Committee of Buffalo, N. Y., and published in the [illegible] Engineer.

[1] Report of R. V. Wheeler on the inflammability and capacity for transmitting explosions of carbonaceous dust.

[2] The explosibility of coal dust. Bull. 20, Bureau of Mines, p. 102.

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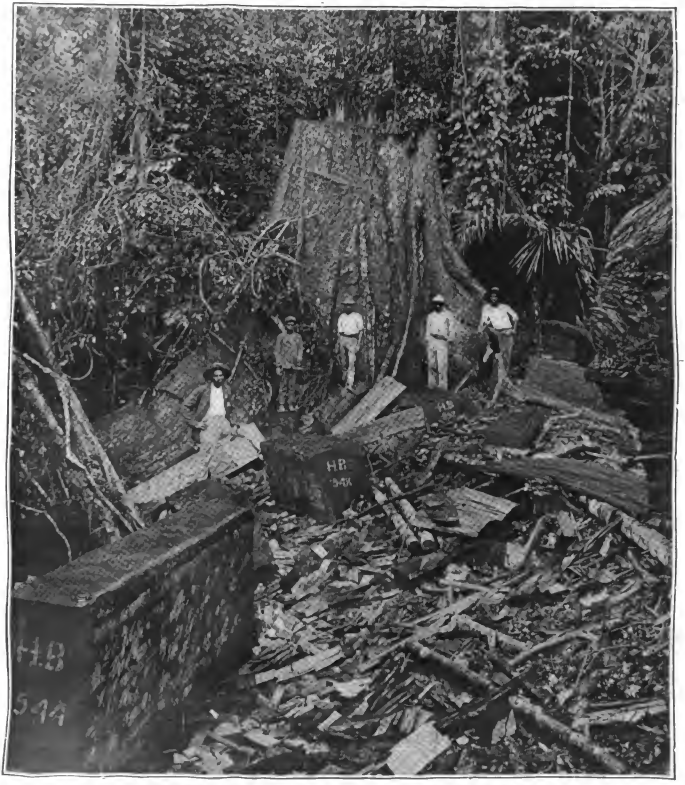

Cutting Spanish Cedar in the Island of Trinidad, showing the high stump that is left standing.

SPANISH CEDAR.—[See page 372.]

Rail Sections as an Element in Steam and Electric Traction—II*

Early History of Track Construction and Developments Made Possible

By P. H. Dudley, C.E., Ph.D., Consulting Engineer, New York Central Lines, New York

Concluded from Scientific American Supplement No. 2031, Page 363, December 5, 1914

STIFF AND HEAVY RAIL SECTIONS.

I designed a series of stiffer and heavier rail sections, after the demonstration and experience with the first 5-inch, 80-pound by the New York Central & Hudson River Railroad, of which the 6-inch, 100-pound section, rolled March 12th, 1892, had been described. The 5½-inch, 80-pound (Fig. 7), of which several hundred thousand tons have since been rolled, was over 40 per cent stiffer than the original 5-inch, 80-pound, and some of the first made in 1892 have just been replaced by the 100-pound.

I made all my sections with broad and thin heads joined to the web with ½-inch fillets and 12-inch radii for all sections under 70 pounds, and 14 inches for those which were heavier. The thinnest portion of the web was above the neutral axis, to form a larger function with the base.

QUALITY OF METAL IN THE RAILS.

When I increased the height of the sections to augment their stiffness for smoother tracks which would check the deflections and reduce the area of contact between the wheels and rails slightly, I knew it would be necessary to increase the physical properties of the metal in the stiffer rails to avoid rapid wear and deformation. I introduced, for that reason, the low phosphorus 0.06 and 0.54 to 0.65 carbon Bessemer steel for the heavier sections. The Boston & Albany rails were rolled in 1891 out of the tougher steel, and I obtained 12 to 16 per cent ductility in the metal under the drop test, which had become obsolete for testing rails until this reinstatement. The specifications were that if 90 per cent of the butts, one from each heat, should withstand a weight of 2,000 pounds falling 20 feet without fracture, and any of the remaining 10 per cent gave 4 per cent elongation per inch before breaking, the heat would be accepted. Less than 5 per cent of the heats failed under the 20-foot drop test. This high grade of steel was made for the New York Central and Boston & Albany railroads from 1891, and continued until the low phosphorus ores were exhausted in 1898.

The metal was tough and tenacious and had so large a duration strain factor that but few breakages occurred in the zero or lower temperatures of winter, and practically none in the summer. I rolled over 500,000 tons of such metal in three-rail ingots for 30-foot rails in the 80, 95, and 100-pound sections. I commenced in 1883 to mark the top rail "A," the second "B," and the third or last rail of the ingot "C." The subsequent service in the track furnished the first opportunity to study the wear of the rails from the different positions of the ingots. The practice of the use of a letter to designate the position in the ingot is general for the railroad companies of the United States for rails and some wheels and tires.

The "A" rails of Bessemer steel with a trace of entrained slag and oxides wore the most rapidly under heavy traffic, but the breakages were not much in excess of either "B" or "C" rails. It was this fact of the service tests of fourteen years that enabled me in 1907 to check the general adoption of a 20 to 25 per cent discard from the ingot. Improvements in making the steel and sound ingots to secure the full ductility of the metal due to its composition, is now the general practice and the wasteful discard is avoided.

REDUCTIONS OF UNDULATIONS IN THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD TRACKS, FROM 1881 TO 1914.

The undulations as summed up by the track indicator in 1881 on the New York Central and Boston & Albany railroads averaged 8 feet per mile, though there were some miles of 12½ feet, and others as low as 5 feet on new rails. The New York Central & Hudson River Railroad has a chart showing the reductions of undulations in the track from 1881 to 1907, as measured by my track indicator. A curve also shows the increase in driving wheel axle loads on the engines. It is instructive and shows that, as the stiffness of the rails increased, the average undulations of the track decreased from 8 feet per mile to 2¼ feet in 1900, while the driving wheel axle loads increased from 30,000 to 60,000 pounds before 1907. The undulations of the track for 1914 are estimated to average about two feet or less per mile. The reductions in undulations of the track, by the stiffer sections as better engineering structures, have lessened the generated wheel effects and enabled heavier wheel loads and trains to be run as steam railway traction progressed.

The Empire State Express was installed October 26th, 1891, with Mr. James Buchanan's 100-ton locomotive, and drew four cars of more than double its weight—the educator of the world for heavy high speed trains. The train to-day is three times its former weight and is composed of eight to ten Pullmans. Freight trains of ninety to one hundred cars of about 4,000 tons are now ordinary, as the train resistance is less per ton for long and heavy trains than for a single unit run by itself.

It is obvious that such progress in steam railway traction has been secured only by the utilization of important principles of construction of the equipment, and the permanent way, which is apparent from observation and experience. There is, of course, difference of opinion for the reasons of the results, and the facts can be learned only by measuring the strains in the rails under the passing wheel loads.

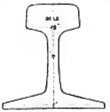

Fig. 7.—New York Central and Hudson River Railroad, 1892.

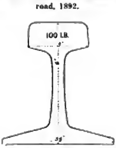

Fig. 8.—New York Central and Hudson River Railroad, 1892.

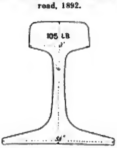

Fig. 9.—New York Central and Hudson River Railroad, 1912.

The original 100-pound section, to meet the progress in transportation, has been increased to a 105-pound section, by the addition of fillets of 1 inch radius to join the web and base, and the web thickened to five eighths of an inch without other changes in dimensions. This was for additional stiffness and strength, and the rolling of basic open hearth steel from 0.63 to 0.75 carbon (see Fig. 9). The new splice bars also fit the original 100-pound and thus join in the track the 100 and 105-pound rail sections.

THE EQUILIBRIUM DEPRESSION BETWEEN THE TRACK AND WHEEL LOADS OF THE PASSING LOCOMOTIVES AND CARS.

The moving wheel loads of the locomotives and cars depress the rails, crossties, ballast, and subgrade from the trackman's surface to the momentary equilibrium depression, and the specific deflections under the wheel contacts of the rails on the flexible crossties are limited by the strains produced in the metal of the section.

The depression is merely momentary for the rails, crossties, ballast and subgrade, for they return practically to the trackman's surface after the train passes.

THE STREMMATOGRAPH.

The stremmatograph is an instrument of precision which I designed, and completed its construction in 1897, to determine the unit fiber strains in the rails when attached to the base between the crossties under moving trains. It is the function of the stremmatograph to make autographic records of the longitudinal unit fiber strains of the elasticity in the metal of the rail section exercised in the base, due to the action of each individual moving wheel load, and its reactions on the flexible supports in the ballast and subgrade. The strains in the base are balanced in the head by those of an opposite character. The strains for a given unit length in the spans of the bending rail controlled by the wheel spacing of the equipment reverse above and below the neutral axis of the section for each passing wheel as a rule, consequently there is a series of alternating unit fiber strains to balance the stresses set up in the metal of the section to carry the wheel load effects. The unit fiber strains or balanced stresses developed in two different rail sections as simple beams of like sections on rigid supports and load are inversely proportional to their respective moments of inertia, according to the laws of mechanics.

The tests on 80 and 100-pound rails with the stremmatograph show for the entire wheel base of the same locomotive with smooth wheels, that the above law of mechanics is equally true for the sum of all the unit fiber or balanced stresses per individual wheel, in two rail sections of different moments of inertia, on the flexible crosstie supports in the equilibrium depression of the track, until a speed is reached where the weaker section develops wheel effects in a faster ratio than the stiffer rails. The track construction and roadbed must be similar for both sections of rails (see Fig. 10).

The comparative tests were made on the New York Central & Hudson River Railroad at Coldwater, N. Y., July, 1913, upon a worn 5½-inch, 80-pound rail rolled in 1892 and laid in track No. 3, and a worn 6-inch, 100-pound rail rolled in 1905, and laid in track No. 4, by the side of track No. 3. The worn 80-pound rails had carried over 300,000,000 tons, and the worn 100-pound, 135,000,000 tons. The moment of inertia of the 80-pound rail had been reduced from 28.5^4 inches to 26.2^4 inches, according to the profile of the head, and were 30-foot lengths spliced with 36-inch angle bars for a three-tie supported joint. The moment of inertia of the 100-pound had been reduced from 48.5^4 inches to 40.77^4 inches, while the rails were 33 feet long and spliced with 36-inch bars for a similar joint to the 80-pound rail.

The ballast was gravel under each track, and the tests were made against the direction of the traffic on the 80-pound rail owing to conditions beyond control, but with it on the 100-pound rail.

The engine was a Mikado; the wheel base was 2-5-2; the total weight of the locomotive was 491,300 pounds; and the total length of wheel base was 68 feet 11 inches. Its tender had the usual two pairs of four-wheel trucks, a total of ten wheel contacts upon one rail. The locomotive was nearly new; the drivers and wheels were of normal rotundity, which rendered possible speeds from 6½ to 60 miles per hour, without the generation of large wheel effects.

The total stresses of each of eight tests upon the worn 5½-inch, 80-pound for one rail, and six tests upon the worn 100-pound rails for a range of speeds from 6½ to 45 miles per hour—140 different wheel effects for the two sections—compare within 1.52 per cent of being inversely proportional to the moments of inertia of the worn rails. Single experiments upon each section of rail for the same speed are within less than 1 per cent of the theoretical comparison. This is proof that the metal in the 80-pound section after its twenty-one years of service, owing to its quality, has not deteriorated in elastic properties in the slightest degree.

These tests involve also another law of the moving locomotive, ascertained by the stremmatograph, namely, the moving locomotive as a machine on good track, distributes its total load through its center of gravity to the several but individual wheel contacts on the rail. Fig. 10 shows the comparative diagrams of the average total stresses for the eight tests on the 80-pound, and six tests on the 100-pound rail. The mean of the total stresses per test on the 100-pound rail was 157,609 pounds, and on the 80-pound, 271,261 pounds, and would be double in each case for both rails of the track.

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* Courtesy of the *General Electric Review*.

The diagrams show the comparative value of the two sections as engineering structures, for the crossties, ballast, and subgrade receive greater intensity of pressures, and must furnish more support for the 80-pound than is required for the 100-pound rails. The capacity and stability of the track of 80-pound rails is less than that of the 100-pound, and therefore exacts more labor in maintenance, for in the practice of engineering the roadbed is strengthened by the 6-inch, 100-pound rail. The rail section on its flexible crosstie supports with its several distributed wheel loads, by the experimental proof in the track of the stremmatograph, follows the laws of mechanics for a single deflection, with the advantage of the required constraint per wheel, and it is one reason why, mechanically, that it has been possible to secure the present progress in steam railway traction.

Jervis's principle of subdivided and distributed loads has empowered, without injury to the rails and roadbed, the use of a heavier total load for adhesion and expended tractive effort to be distributed through several wheel contacts for locomotives and electric motors, than was formerly possible through a single pair of drivers, or the 4-4-0 class of locomotives. The wheels of the engine and tender must be included for the total stresses of the steam locomotive, therefore the tender running gear must be included for the wheel effects for each class of locomotives. The 4-4-0 would have the following designation: 4-4-0 + 4-4, or eight wheel contacts on one rail. This class has been superseded by the 4-4-2 + 4-4 for heavy passenger service, and this in turn by the 4-6-2 + 4-4 class. There are a number of railways with mountain gradients and rails of 90-pound or less per yard where the class of locomotives of 4-8-2 + 4-4 is used to advantage. For freight service of slower speeds and larger train loads, the Mikados of 2-8-2 + 4-4 are in general use, and a class of 2-10-2 + 4-4 are employed when a larger tractive effort is required. The loading and constraint of the rails in the equilibrium depression would be still better with a classes of 4-10-2 + 4-4 wheel base and drivers about 57 inches in diameter.

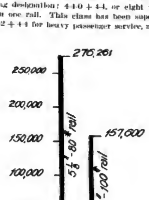


Fig. 10.—Comparison of total stresses on worn 5⅝-inch, 80-pound and worn 6-inch, 100-pound rails under the same locomotive. New York Central and Hudson River Railroad, July, 1913.

BASIC OPEN HEARTH RAILS.

The progress in transportation during the past few years has required the replacement of Bessemer rails of 0.10 phosphorus and 0.50 carbon, by basic open hearth steel of 0.04 phosphorus and 0.65 to 0.75 carbon, for 100-pound rails or over, to secure a duration strain factor of the metal which would carry the high speed trains in temperatures of 30 degrees below zero without fracture of the rail, as so frequently occurred in Bessemer steel.

The unit fiber stresses of 18,000 to 20,000 pounds under a driver of 30 miles per hour would be applied from zero to the full amount in about 0.04 of a second, and at 60 miles per hour it would be 0.02 of a second from measurements by the stremmatograph. This is quick time for the application and distribution of such large unit fiber strains which are balanced by the limited stresses set up in the metal. The basic open hearth rails, from the experience with them in the track, prove to have a greater duration strain factor in the metal than it was possible to secure in all of the 0.10 Bessemer steel rails at the low temperatures. The rails are made under the specifications for the New York Central Lines elongation and ductility tests for basic open hearth steel rails which were introduced in 1910, to secure those of the maximum ductility, purity, and homogeneity of the steel, due to its chemical composition for service in temperatures 30 degrees below zero F.

The drop tests are made from each melt, one from the crop of the top bar of the second, middle and last full ingot. The crop, 4 to 6 feet long, is stamped with a spacing bar of six 1-inch spaces in the center of its length on the base, head or side, as desired.

Each butt for basic open hearth rails for acceptance of the melt, must show under the drop of 18 feet for the 80 and 90-pound sections, and 20 feet for the 100-pound section, at least 6 per cent elongation for one inch, or 5 per cent for two consecutive inches before fracture. The elongation of each of the six spaced inches is measured by a flexible rule, divided into hundredths of an inch, therefore the increased one-hundredths after the drop give the percentage of elongation per inch of the metal. The ductility is completely exhausted in one test for each metal, and is made in rotation from the different ingots in succeeding melts. The melter has the ductility of the last melt before he taps another from the same furnace, which has enabled a greater uniformity of the steel to be obtained than was possible before the tests. The specifications for the ductility tests have been adopted by the American Railway Engineering Association for use by the railroads in the United States.

THE WHEEL PROBLEM.

The wheel consists of a tread constructed of uniform radius revolving upon its axis of lesser rolling and with less axle friction than would be produced by sliding on its support, and is the mechanical embodiment of a principle for transportation so ancient that its origin is unknown. The wheels and drivers are the only contacts on the rails to support and carry the equipment, and it is requisite that the material of their treads should be homogeneous and able to maintain their rotundity for a considerable length of service.

A 36-inch wheel makes 560.2 revolutions per mile and for a static load of five tons the repetitions upon the metal of the tread are equivalent to 2,801 tons per mile. To run from New York to Chicago, the applied static tons per mile equal 2,718,164 mile-tons per wheel for the trip, exclusive of generated wheel effects.

The New York Central Lines are giving special attention to the wheel problem by measuring the wear and deformation on thousands of sections of marked wheels to secure a metal in the wheel treads which will maintain their rotundity under the large mile tons of service and the action of the brakeshoes to control the trains.

ELECTRIC TRACTION.

The principles and practice elucidated by the stiff rail sections for steam railway practice apply equally to electric traction. The latter has the advantage for city traffic, for imbedded girder rails on rigid supports with welded joints can be used to carry millions of tons of traffic before the track requires adjustment or renewal of the rails.

Electric traction has rendered possible the large underground terminals like the New York Central & Hudson River, the Pennsylvania, and the Hudson & Manhattan railroads, and the subways in New York city. The ten and twelve-car multiple unit trains with two to five minutes headway, and all the appliances for safety of control in their movements, are models of electric traction.

The trolleys in the cities and country roads are usually contructed with light T rails which could be replaced with advantage by stiffer sections.

The electrical engineers have the unique problem of developing motors on similar principles to those that determined the evolution of the steam locomotive.

RESISTANCE OF STEEL RAILS AS ELECTRIC CONDUCTORS.

The 70-pound contact rails for the Grand Central Terminal were made of Bessemer steel in 1905, and continue to the present time, of the following desired composition:

Carbon	0.10
Manganese	0.40
Silicon	0.05 or less.
Phosphorus not to exceed	0.10 and as much less as possible.
Sulphur not to exceed	0.08 and as much less as possible.

The manganese was just sufficient to roll the steel which gave a resistance of 8 to 8½ times that of copper. The resistance in some of the recent Bessemer 70-pound contact rails is from nine to ten times that of copper, though the higher figure is from the upper part of the ingot, and doubtless was rolled cold. The resistance of a 70-pound New York Central & Hudson River Railroad standard section of the ordinary composition for the rail was 12.5 times that of copper; of the 100-pound Bessemer, 11 to 12 times; while the 105-pound section in basic open hearth steel is only about 10.6 times.

Basic open-hearth 70-pound contact rails can now be obtained of about 0.10 carbon, but with phosphorus and sulphur each under 0.04, in which the resistance is guaranteed to be not over seven times that of copper. This needs confirmation for the steel of the entire ingot.

The strap iron rail with its 6 by 6 inch wooden stringer for the girder of the Mohawk & Hudson Railroad of 1831, and the 6-inch steel section of 1882, are historic illustrations of the progress of railway transportation as governed by the rail section.

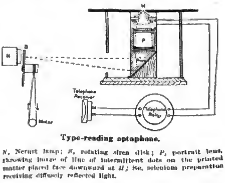
The Type-Reading Optophone*

By E. E. Fournier d'Albe

Any instrument designed for translating optical into acoustic effects, or light into sound, and thus to some extent substituting the ear for the eye, may be appropriately termed an "optophone." The intermediate link is either heat or electric current, and in view of the fact that a current of a few thousandths of a microampere is audible in the best modern telephones (if intermittent), one would naturally use an electrical rather than a thermal link. This is done in the various forms of "optophone" devised by the author since the Optical Convention of 1912.

The latest of these, described before the Royal Society on May 28th, and shown at the conversazione of the society on June 10th, is designed with the object of enabling blind persons to "read" ordinary letterpress by means of the ear. The accompanying illustration of the optical arrangement is reproduced from the Royal Society paper by permission of the council.

An optical system throws the image of a glowing Nernst filament upon the printed paper, laid face downward on a suitably perforated desk. This image is broken up into a series of seven or eight luminous dots, flashing with different musical frequencies, by means of a rotating siren placed immediately in front of the Nernst filament. Some light-sensitive preparation, preferably of selenium, is placed close to the type so as to receive whatever light is diffusely reflected by it.



Type-reading optophone.

N, Nernst lamp; *S*, rotating siren disk; *P*, portrait lens, throwing image of line of intermittent dots on the printed matter placed face downward at *H*; Se, selenium preparation receiving diffusely reflected light.

The size of the image is made to fit the kind of type to be read, and a sensitive telephone is put in series with the selenium and a battery with one of S. G. Brown's telephone relays.

It has been found possible to obtain an "audible" sound from type of the ordinary newspaper size. The straight black stem of a letter produces silence, and a curved letter, such as S, produces in its passage a set of gradually changing notes which are characteristic of the letter, and cannot be mistaken even after only a few minutes' practice. To learn the entire alphabet in this way should be a matter of a few weeks or months, but the amount of practice required will vary very greatly from one person to another, as only a "musical" ear can readily detect the omission of certain notes from a given chord. Given an adequate alinement and line-changing mechanism, there is no reason why, with sufficient practice, ear-reading should not be almost as rapid as ordinary reading at sight.

The choice of type is, of course, unlimited. There is no arbitrary element in the determination of the sounds required to represent the various letters, as each type will automatically produce its own characteristic sounds. With considerable practice, a blind person, thus trained to allocate certain notes to certain positions, should be able to construct "instinctively" a visual (or tactile) image of any new or unfamiliar letterpress type at the first hearing.

Effects of the War on Employment in Germany

According to figures recently published in Germany, about 21 per cent of the workmen of that country are out of employment. This estimate is based on reports made by a number of labor unions, and represents the average. In some trades as much as 62 per cent of the men are unemployed. The reports of thirty-four unions, with a membership of over a million and a half, from which only 1,260,000 replies were received to inquiries sent out, 268,459 were unemployed, and 2,254 others were wandering about the country seeking work. In the wood-workers association 24 per cent of its members were out of work, according to a census taken late in September.

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* From *Nature*.

Logging scene in the cedar forests of the Island of Trinidad.

Spanish Cedar

Sources of Supply of this Substitute for Mahogany

SPANISH cedar (*Cedrela odorata*) is one of the standard woods imported from tropical America. There are a good many uses for which it is preferred to any other material, and it is a very satisfactory substitute for mahogany in many cases where figure is not an important object. It is eminently desirable that its supply should be regular and adequate to the demand, but for a long time now there has been a shortage of stock in Spanish cedar for making cigar boxes, its chief use in this country. The market is often practically bare of reserve stock, and the prices have advanced to such an extent that consumers have been obliged to seek other materials as substitutes. The principal woods now used in place of Spanish cedar for cigar boxes are the yellow poplar (*Liriodendron tulipifera*) and West African cedar of okume (*Boswellia klaineana*).

This condition is due chiefly to a scarcity of supply and the growing demand for the wood in the cigar-box industry. Both of these causes are operating together in pulling up the prices of this wood. The cedar territory is naturally becoming restricted and it is yearly more difficult to get out the logs. There was a time when Cuba, and comparatively small areas in far southeastern Mexico, turned out immense quantities of cedar. In Cuba it was the leading wood, being rivaled only by mahogany. But now the vast bulk of the mature trees have been cut away from all the sections where it was readily accessible, leaving the less accessible areas in Mexico, Central America, Trinidad, and Colombia to furnish the bulk of the supply. Cedar has been drawn in large quantities from southeastern Mexico, where there is a belt from twenty-five to one hundred miles wide; but the operations up to this time

Spanish cedar logs on the quay at Port-of-Spain, Trinidad, ready for shipment.

have resulted in clearing away the more accessible portions of the supply, leaving the remainder almost out of reach of the loggers. In a few places logging railroads have been put in, but for the most part dependence is placed upon the streams, and these are extremely uncertain except through the rainy season, when the logger must be in readiness with his supply of logs in order to get them to the place where they are loaded on steamers for shipment to the foreign markets.

The question of much interest to the dealers and consumers is as to whether the present supply and prices can be maintained. It is possible that new territory may be opened up in the interior portions of Mexico, which would bring an increased supply until the concession is exhausted. In view of the increased cost of logging under such circumstances there would be no possibility of lower prices than those that now prevail. Spanish cedar can not be cornered, and there is a great deal of it still left, but its location and the high cost of getting it out and transportation to market preclude any great enlargement in the supply or lowering the price. The various phases of this subject are identical with those which have governed the supply and price of true mahogany in the markets of the world.

Comfort for Workers in Washington's Government Buildings

Necessity for Modern Sanitary Conditions Now Being Recognized

By Day Allen Willey

MANY of the employees of the Government in Washington have been compelled to work day after day in dingy old buildings, walking up and down the steep stairways because no elevators would reach their offices. Typewriting, bookkeeping and performing of clerical work has been performed in ill-ventilated, dark offices with hard-back chairs or stools to sit on.

Considering the faithfulness and skill of these men and women, and their devotion to duty, the Government has been severely criticised in past years for keeping these workers in such uncomfortable and unhealthful offices. At last, however, some of the Senators and Congressmen have begun to give more thought to these thousands of toilers in the capital. As a result in the Department of Agriculture the majority of the army of busy workers for the interest of farmers now have offices in modern buildings of attractive design with roomy, well lighted apartments, ample toilet facilities and hooks for clothing, while elevators do away with the effort of climbing up and down stairs.

Another building that has been an eyesore of our capital was the Bureau of Engraving and Printing, where much of our currency is made. For years, workers have been crowded together in hot, dirty rooms, the floors greasy and stained with oil and littered with scraps of paper. The law compelled them to remain within the building the entire day for fear some employee might steal the valuable paper on which the bank bills are printed. Consequently, all the workers had to bring their noon lunches with them, and eat within the Bureau, finding a place where they could sit, such as an empty box, a stool or perhaps the stairways leading to the rooms.

Uncle Sam has at last given thought to these care-worn money makers and has provided a building for this bureau that is one of the most attractive in Washington, and is really a factory home in the many provisions made for the comfort of those who labor within its walls. The new structure consists of a main building of sandstone and the sides and ends of the wings are devoted almost entirely to windows, with the glass set in metal sashes. It has been estimated that 32,000 large panes of glass are required for the windows of the buildings.

The total floor area of the building is 476,700 square feet, and the cubical contents are about 7,000,000 square feet. In planning this new factory especial attention has been paid to the health and well-being of the employees.

A man who is well fed is in better condition to render good service than he who is in need of proper nourishment. Hence the installation of a co-operative lunch room in the new building. It is the duty of the physician in charge to supervise the sanitary conditions of the establishment. Each day he inspects the entire building, enforcing the utmost cleanliness, insuring every employee the necessary amount of ventilation in the room in which he works, studying lighting conditions and relieving eye strain. In addition he is always present to administer first aid to any in case of accident or relief in lesser ailments. In the new building pamphlets will be issued relating to the special illnesses likely to be met with in this sort of work.

It has been planned that the employees shall operate the lunch rooms themselves. The Government has furnished all necessary equipment with the exception of dishes, silverware, linen and such accessories, which will be provided by the employees. An association of the workers has been formed for the purpose, women employees subscribing 50 cents each and the men $1 each. In this manner a fund of $2,000 has been raised. It is planned to refund the subscription as soon as the finances will permit. The lunch rooms are not to be operated as money-making propositions, and the food will be sold at the lowest possible figure.

Another advantage of the new bureau is that all of the mechanism is operated by electric motors except the preliminary work.

The methods of turning the sheets of linen paper into bills have been greatly improved in the new plant. First the sheets are dampened so that they will take a good impression from the printing press. Then they are placed upon presses where lettering and other characters are placed only upon the back. From these presses the sheets are taken to steam driers, where they are dried to set the printing ink. But before anything further is done, the sheets must again be moistened, after which they go to the electric printing presses and the front surfaces are lettered and stamped. After a further drying in the steam chests they are put upon the machines which place the number of each note in the proper position upon it.

The partly finished money is now ready for the counters. These are all women, and the rapidity with which they work is really wonderful, as the visitor sees them picking up sheet after sheet so rapidly that he can hardly distinguish one sheet from another. The counting is done to make sure that none of the money sheets have been lost or destroyed in any way; and after it is completed the currency in the form of sheets, each containing from four to eight notes, is ready to be carried in the big wagon to the Treasury.

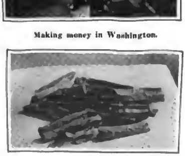
At the Treasury there is very little work to be done by machinery except to put on each note what is called the seal. This is really a most artistic and beautiful piece of work, and is one of the most difficult designs to counterfeit. The sealing presses are operated by electrical machinery, and finish all of the currency issued through the national banks of the United States.

Half a million dollars in new notes.

Making money in Washington.

Numbering with colored inks on electric press.

Money in the vault ready for shipment to banks.



Charred bank bills sent for redemption.

Separating charred bank bills.

When the sealing is finished and the mechanical knives cut the sheets into the ordinary bank-notes, machinery has done its work; but in this building the money is counted and recounted so that there can be no possibility of a mistake.

On the second floor is a vault for the safe keeping of paper money after it has been completed and numbered. This vault is the most secure of any apartment in the building. The interior is about 50 by 20 feet and the ceiling 15 feet in height, with the walls constructed of reinforced concrete. Between the reinforced concrete portion of the walls and the outer coating is a mesh of electric wires. Should any of these be touched by an intruder, an alarm is automatically sounded in the office of the captain of the watch and also in the Treasury building many blocks distant.

An elaborate system of signals is employed in the building. There is a watchman's time detection system, with stations for reporting in each section of the factory, and in addition to a complete telephone system, there is another method for calling the various division superintendents to the office of the director. Another innovation is the division reporting system. By means of red, white and green lights the superintendent of each division will report to the captain of the watch at the closing hour whether his section is "clear"; that is, if every sheet of stamps or money and every printing plate has been accounted for at the conclusion of the day's work, and has been checked and sent into one of the vaults, the superintendent will operate a switch which will light the white bulb in the office of the captain of the watch. In case something is missing the red bulb will show a light, and this will order the division held until the missing article is accounted for.

In case of fire, on breaking the glass in any one of a score of stations an automatic device releases the pressure of a chemical engine, and a pipe system extending throughout the entire building is immediately filled with a chemically charged liquid such as is used in hand extinguishers. At twelve points on each floor a 75-foot hose is attached to the chemical system and a valve at the end of each pipe connection regulates the flow of the chemical.

The workers of the Bureau of Engraving and Printing have come to be known as the world's model working force. They manufacture enough paper money each day to carpet five acres, and the same force turns out enough postage stamps to stick on every inch of a six acre surface. Eleven acres might be covered with the revenue stamps they turn out each day. Of the 4,800 employees, there are 200 more women than men.

How to Determine Type of Motor*

Determining by the Leads Whether a Direct-Current Motor is Shunt, Series or Compound Wound

By F. A. Annett

"What kind of a machine am I working with?" is a question that often confronts the electrician or engineer. In the medium- and large-size machines (2 horse-power and up) this can usually be determined by inspection of the armature and field leads.

First, see if both the armature leads go to the external terminals, how many leads come from the field coils, whether they go to the external terminals; also, if there are small auxiliary poles (interpoles) between the main poles.

Assume a condition as in Fig. 1, where two leads come from the armature and two from the field coils which connect to four external terminals. If this machine is series wound, the armature and field leads will both be the same size, and of large cross-section. Sometimes, especially in small machines, one lead of the field is connected to one lead of the armature and only two terminals are brought out of the motor, as in Fig. 2. This does not alter the conditions, however.

If the machine is shunt wound, only the armature leads will be of large cross-section, while those of the field will be small, as indicated in Fig. 3. Also, the field terminals (lugs or connectors) will be small, while those of the armature terminals are large. On the series motor the field and armature terminals were large and of the same size. In some shunt motors a field and an armature lead are connected inside the machine and brought to the one terminal, as in Fig. 4. Again, in some very small machines the field coils are connected in multiple with the armature and only two terminals are brought out.

If the motor is compound wound, it will have two sets of fields. The series and the shunt coils are usually made up separately and placed on the polepieces, although in some cases the two coils are taped together before they are placed on the polepieces and look much like one coil, but they will always have four leads, two large and two small. These, together with the two armature leads make six, which may be brought out to six terminals, as in Fig. 5; or one shunt and one series-field may be connected to the same terminal, as in Fig. 6. Again, one of the series-field leads may be connected directly to the armature (brush), as in Fig. 7, making only four external terminals. As far as the number of terminals required to connect the motor to the ordinary starting box is concerned, the other series-field lead and one of the shunt-field leads may be connected together, making only three external terminals, as in Fig. 8. In general practice, however, compound motors have five or six terminals, as in Figs. 5 and 6.

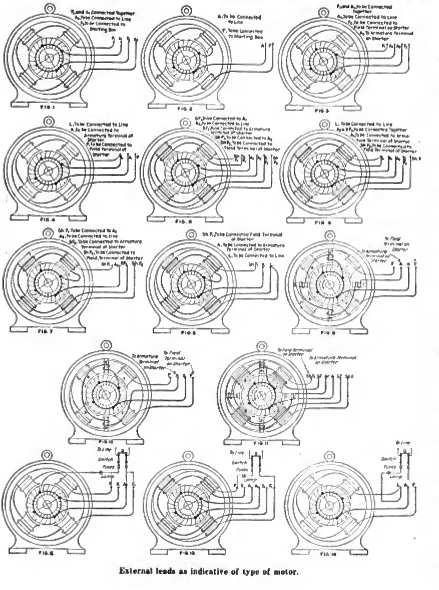
The large terminals are those of the series-field and the small ones those of the shunt field. This is very marked in the larger machines, the series-field often being made of copper bar. The series-field usually occupies from one-quarter to one-third the space on the polepieces occupied by the shunt-field coils, and may be placed either on the end of the polepieces near the armature or back against the frame.

If the machine is of the interpole type—that is, with auxiliary poles between the main poles—the interpole winding will always be in series with the armature. Like the series-field winding, it is of large cross-section as represented by the heavy lines in Figs. 9, 10 and 11. Referring to these illustrations, it will be seen that an interpole winding does not necessitate any additional terminals on the outside of the machine as one lead of the interpole is connected to one armature lead, leaving but one armature and one interpole lead to be brought to the outside terminals.

In the different classes of machines considered, the armature windings are the same, each machine deriving its name from the field winding and its connections.

One thing that can be kept in mind is that a series motor is seldom used except in railway, electric-vehicle and crane service. In some cases, however, they are used to drive small pumps and blowers, but these are usually limited to sizes of 2 horse-power and less. It is on the small-size motors that it is the most difficult to distinguish the different types; for instance, by referring to Figs. 1 and 3, both motors have four terminals brought to the outside and in sizes below 2 horse-power the leads from both the armature and field coils are the same size, so it becomes necessary to make some kind of a test to determine whether the machine is shunt or series wound. This can be done by testing with a lamp.

First, place one terminal of the test circuit on the brushes, and with the other terminal connect to the various motor terminals until the lamp is lighted, as will be the case when connected as in Fig. 12. This will indicate an armature terminal. If one side of the test circuit is connected to terminals *F* or F_1 while the other side is connected to the brushes, the lamp will not light, as these are the field terminals, but when the test is made to


A. To be Connected to Line
F. To be Connected to Starting Box
L. To be Connected to Line
FIG. 1
FIG. 2
FIG. 3
FIG. 4
FIG. 5
FIG. 6
FIG. 7
FIG. 8
FIG. 9
FIG. 10
FIG. 11
FIG. 12

External leads as indicative of type of motor.

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* Reproduced from *Power*.

terminal *A*, the lamp will again light. This will indicate the other armature terminal of the machine.

After the armature terminals have been located, connect the test circuit to terminals *F* and F_1, as shown by the dotted lines. If the lamp lights dimly the machine is shunt wound, and if brightly, the machine is series wound; also, if it is shunt wound a severe spark will occur at the field terminal when the test circuit is broken. This will not be the case if the motor is series wound.

There is another way that the machine can be tested to find if it is shunt or series wound, in case a test lamp is not available. First, connect the field and armature in series, as shown in Fig. 2, and the remaining terminals to the line. If the motor is series wound it will start up with a strong effort and will soon reach a very high speed if not loaded. On the other hand, if it is shunt wound, if it starts at all, it will be with a weak effort and at a very slow speed. In most cases, it will not start at all, but if the armature is turned by hand it will be found to have a tendency to turn in one direction, and when the line switch is open, there will be a severe arc.

In case the machine is compound wound and connected as in Fig. 7, there would be four terminals appearing on the outside, as in Figs. 1 and 3, so along with making the test as described above it will be necessary to see that one of the armature terminals does not connect direct to the field coils. The terminals of a compound motor with its leads brought out, as in Fig. 5, may be located as follows:

First, test for the armature terminals as described in connection with Fig. 12; then connect one side of the test circuit to one of the four remaining terminals, such as *F* in Fig. 13, and then with the other test terminal make connections first on one and then on another of the three terminals, such as F_1, until the lamp lights. The test lamp is connected to the field winding shown in fine lines which indicates it is the shunt, and in that case the lamp will burn dimly, due to the high resistance of the field coils, and when the circuit is broken, a severe arc will occur as described for the shunt motor. This leaves two remaining terminals to be tested. When the lamp is connected to them it will burn brightly for the series field always has a low resistance. This is also true of the armature.

When one side of the armature and one shunt-field lead are connected to the same terminal, as in Fig. 4, and it cannot be seen just what terminals the leads run to, a test can be made as follows: First, disconnect one armature lead at the brushes or raise the brushes from the commutator. In Fig. 14, one armature lead is shown disconnected from the brushes. Connect one side of the test circuit to this armature lead. With the other side of the test circuit, test the outside terminals until the lamp lights. It will burn brightly if connected to terminal *L*, whereas, if the test circuit is connected to terminal *F* instead of *L*, it will burn dimly, for now the field is in circuit. When the lamp burns brightly, it indicates that the armature lead goes direct to terminal *L*, and when dimly that the field is connected to *L* and *F*. If one side of the test circuit is connected to the brushes and the other to terminal *A*, it will again burn brightly, but if one test wire is allowed to remain on the brushes and the other is placed on *F* or *L*, the lamp will not burn; this will indicate that the armature lead alone connects to *A*.

In a great many cases the manufacturers mark the terminals, and in most cases these marks can be relied upon as being correct when the machine comes from the factory, but if the machine is repaired it is not always in reliable and careful hands, and in some cases these markings are mixed up, consequently, the safest and surest method is to test the machine before it is connected up.

The Prismatic Astrolabe*

By David Rines, United States Naval Observatory
Washington, D. C.

The method of equal altitudes for the astronomic determination of the observer's position upon the earth's surface leads to results of such surprising accuracy that it has been termed incontestably superior to any other. As the name suggests, this method calls for the observation of celestial bodies in various portions of the heavens, but always at the same altitude, the observation consisting merely in noting the time when this altitude is attained.

As the altitude itself is entirely eliminated from the results in the course of the computation, its exact value, affected by constant errors of graduation, eccentricity, level, collimation, azimuth, flexure, etc., is of no consequence, provided only that it is the same for all stars observed. The local time and the latitude thus obtained, free from systematic error due to these sources, are remarkably precise.

The method itself was introduced by Gauss, who first pointed out its advantages a century ago. Employing a sextant and artificial horizon, this illustrious mathematician, even with such crude apparatus, and with only three stars, obtained a value for latitude which excited wonder. After Gauss, others experimented with the sextant; but only the brighter stars can be observed with this little instrument. Very few of these can be found at a given altitude within a reasonably short period of time, and the small magnification necessarily employed to permit keeping the star in the field of view is not conducive to sharp observation. Sextant work cannot be relied upon for work of extreme precision.

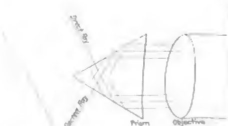

Fig. 1.—Elements of the prismatic astrolabe.

Experiments were accordingly made with theodolites and other instruments rotatable around a stable vertical axis, and very good results were obtained by careful manipulation; but the artificial horizon was here replaced by some device like the spirit level, and this reintroduced the bugbear of systematic error. The method of equal altitudes, therefore, despite its advantages, though employed extensively at sea, was long neglected on land.

Recently, the French took hold of the problem, and, in their ingenious way solved it by inventing and improving a new instrument, "l' astrolabe à prisme," "the astrolabe with a prism," or the prismatic astrolabe. Of this, there are several forms, but the principle in all is the same. Like the sextant, the astrolabe involves the use of an artificial horizon, but it replaces the two separate sextant mirrors by a single equilateral glass prism. The prism is mounted, edges horizontal, with rear face vertical, in front of the object glass of a horizontal telescope rotatable on a vertical axis in a horizontal plane, and the whole—prism, telescope, mercury basin and other appliances—is supported on a tripod like a theodolite.

One face of the prism receives light directly from the star, another from the star's image reflected in the mercury, and the two light rays, after interval reflection, pass through the rear face of the prism to the object glass. Stars are thus observed at a constant altitude of 60 degrees.

For time determination, observations are made in the neighborhood of the prime vertical, where the altitude changes most rapidly; for latitude, near the meridian. As it is easily possible without field illumination to observe stars as faint as the seventh magnitude, a skillful observer may secure thirty to forty stars in less than an hour, and this number is sufficient to give very good values for both time and latitude.

An interesting feature of the astrolabe is that, unlike other instruments, the results obtained, if the prism be well constructed and by employing reasonable care, are almost entirely independent of errors due to maladjustment. The telescope should be perfectly horizontal; so also should the prism edges; and the rear face of the prism should be vertical. If, however, the prism edges, for example, are not horizontal, the skilled observer will recognize this fact when he perceives the motion of the star in the field of view and a slight touch of a screw eliminates the inconvenience; indeed, this adjustment is generally effected on every star.

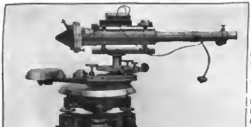

Fig. 2.—Prismatic astrolabe for determining latitude and time by the method of equal altitudes.

The one important adjustment—and even that is not absolutely essential—is the perpendicularity of the rear face of the prism to the axis of the telescope, which is easily effected by aid of a simple auxiliary device. If the adjustments are not perfect, the only error involved is in the observed altitude which, instead of being 60 degrees, may be some larger or smaller quantity; but if care is taken to make all observations in the same portion of the field, and in the same way, this quantity will be the same in all positions of the instrument. All stars will be observed at the same altitude, and the resulting latitude and local time will be unaffected. With the newer type of prismatic astrolabe, permitting temporary field illumination, this condition is easily fulfilled.

There are no instrumental constants to be determined, and consequently there are no systematic errors introduced by such constants. There are no circle measures, with the danger of reading and recording them incorrectly. There are no errors of nadir, pointing, thread inclination, pivots, etc., such as affect observations with other instruments. In fact, nearly all constant errors, affecting all observations alike, are eliminated. There is danger of systematic error introduced by the personal equation in noting the times of observation, but almost all other errors are of the accidental class, and may be eliminated by increasing sufficiently the number of observed stars.

The manipulation of the instrument is simple, rapid and easy. Guided by a previously prepared list of stars containing approximate times and azimuths, the observer first sets the telescope in azimuth, then seating himself at the eye end, watches the star and its reflected image enter the field of view from opposite directions. He touches a screw, perhaps, to cause the images to change slightly their relative positions, or to bring their vertical line nearer the center of the field. As the images draw closer in their approach toward each other, he concentrates his attention and at the moment of coincidence makes a record of the time, either by the eye and ear method, or by the chronograph and key. In this record is comprised the whole observation.

The computations both preliminary to and succeeding the observations are long and tedious. An hour's observing list requires many hours of preparation and subsequent computation. The labor of preparing the observing list may be considerably shortened by tables and other aids; and the final computations, too, may be made more easy by tables and graphic processes. The fact, nevertheless, remains that the computations are time consuming. In view of the high precision attainable, this objection should carry but little weight, particularly when it is remembered that the computations may be made at one's leisure, long after the observations have been completed.

The instrument is comparatively inexpensive, it is light and portable, and requires no previously established stable foundation, but may be set up in a few minutes. These considerations should recommend it particularly to geographers, explorers, surveyors and other travelers who seek accuracy, yet do not wish to encumber themselves with the comparatively heavy portable transit and accompanying chronograph. For the very finest kinds of longitude work, however, owing to the personal equation, the astrolabe should be looked upon with suspicion. Yet it should be remarked that it has been used side by side with portable astronomic transits of the best known types, and the results obtained by the two different kinds of instrument have been wonderfully close.

The prismatic astrolabe has been employed by the French on boundary and other survey work in their colonies, in the measurement of a meridian arc in Ecuador, and more recently in important wireless longitude determination. It was used in the spring of 1913 in the preliminary operations attending the determination of the difference of longitude between Washington and Paris.

The astrolabe may be employed for absolute longitudes by observing equal altitudes of stars and of the moon. It can advantageously replace the portable transit in much of the longitude work now carried on in this country, and would result in considerable saving. Among other applications, it may be employed at fixed observatories to determine star positions. Our astronomers and engineers should give it a trial.

For an exhaustive discussion, the reader is recommended to A. Claude et L. Driencourt, "Description et Usage de L' Astrolabe à Prisme."

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* From *Engineering News.*

The Effect of Water Pressure Upon the Form of Fishes

A Study of Evolution of Form Resulting from Conditions of Life and Habits

An interesting account is given in *La Science et la Vie* of the effect of water upon the form of fishes. The article is written by Frédéric Houssay, professor at the Sorbonne. In his hands comparative anatomy has developed into dynamic morphology, which seeks to explain the characteristics of animal forms as the direct or indirect reactions from the action of the surrounding world.

In the article on the shaping of fish by the pressure of water, Prof. Houssay tells us that naturalists for a long time have agreed in admitting evolution in living beings. Nearly all scientists at the present moment find no difficulty in believing that the infinite variety of animal forms, now existing or extinct in the course of geologic ages, is the result of incessant changes carried on without intermission. These changes take place with a slowness or an infrequency which prevents us from perceiving them readily in our short life. One can, though, very easily imagine that these modifications, suspected or recognized on a small scale, produce in the course of time very important results. Difficulties commence and arguments begin when it is sought to specify how such an evolution takes place.

A great many scientists believe that the ability to change is a quality innate in all living beings, an essential characteristic, and that evolution is to some degree no more than the exercise of this faculty, than the realization of this inner power. Others who are still in the minority, but whose numbers are growing and among whom our author must be counted, are unable to believe that a living being is capable of modifying itself when there is no change around it. They consider the changes in creatures as the reproduction or the reflection of the changes that take place near them, and that these surrounding changes are themselves united by an unbroken and gradual connection with all that takes place everywhere in the infinite world.

It is plain that one cannot do everything at once and that it is necessary to attack this problem a section at a time. Thus, our author has been led to try to solve the definite question of the form of fishes, and to inquire into the role which the surrounding medium, that is the water, has been able to play in the construction of this form.

As, in the present discussion, the question will always be of water in motion, and even in vortex motion, we must regard this fluid, in the matter to be elaborated, as both elastic and oscillating.

Although it looks simple this question of the form of fishes is one of the most difficult, and our scientist does not claim, in the course of a short article, to go into it in detail with the exactness he showed in the work already mentioned on the "Form, Strength, and Stability of Fish." He merely tries to indicate the succession of ideas and the course of the demonstration.

First of all, it is necessary to agree on the fish form which shows variation. Leaving aside all those which are too long or too flat, such as the eel, the ray, the sole, plaice, dabs, and the turbot, let us take simply the actual swimmers in open water, for example, the shark, trout, salmon, the maigre, red mullet, sardine, herring, mackerel, and even also the carp and the dolphin, which are already a little flattened at the sides, but not yet too much.

In order to understand how water has been able to mold the fish, it is necessary first to grasp the idea that all creatures are plastic, that is to say, can suffer deformation under pressure, exactly like potter's clay under the finger, less quickly, it is true, but as certainly and as completely if the time required is given.

"Suppose we explain what is meant," says our author, "by an example chosen among thousands. Everyone knows that a child that carries itself badly becomes mis-shapen by allowing his weight to exercise pressure unsymmetrically. On the other hand, the deformity can be rectified by an appropriate compression. If then in several years light pressure can modify a body under our eyes, what cannot be expected of far greater forces which have been working without cessation for ages upon ages?

"What then is this far greater force which we allege? It is the resistance of water; it is an enormous force. The power of this force can be very simply tested by plunging the arm in water and trying to move it there rapidly. It will soon be seen that the resistance varies considerably according as the hand is placed flatwise or edgewise. The water will even turn the hand edgewise, if the muscles of the forearm are not stiffened and the hand is left limp in concentrating all the force in the upper arm and shoulder in order to obtain the movement. It is known, moreover, that this resistance is proportional to the square of the velocity of displacement.

Having at our disposal the plastic living being, and the great molding force, it is further necessary to define the conditions in which the latter acts upon the former. The two essential necessary and proper qualities for selecting a fish with a plastic frame are that he should have the power of rapid movement, and that he should have the same density as the water. All well-made fish weigh, in equal bulk, it may be said just as much as water, hardly more, hardly less. That removes from our investigation all vertical force drawing toward the bottom or the surface.

If one change is introduced everything changes. Thus, the deformed or badly shaped fish, those too long or too short, are decidedly heavier than the others or the water. On the other hand, some, as the mola or moon-fish, are decidedly lighter, and become mis-shapen at the surface, while the former grow mis-shapen at the bottom of the water.

Creatures which might be still heavier, and also less rapid in movement, would not be formed at all in the shape of fish, but in that of annelids and crustacea. Creatures heavier still, as well as more sluggish, would become creeping mollusks; and others, absolutely heavy, which do not move at all, attach themselves to the algae, to the rocks, or bury themselves in the mud, and are thus molded.

This is the reason why the resistance of water, which is always the same, does not always produce the same effect, because it is not always exercised in the same way; and why all aquatic existences, equally plastic, but of various weight and rapidity of movement, are not alike.

"This much being clearly understood, let us see by experiment how water can model a body that is plastic, quick in movement, and of uniform density, and which weighs just as much as an equal volume of water.

"And first of all, how should one experiment to put himself in the same conditions as those under which a fish swims? The latter gives a short stroke of its tail to the right and left, and then moves ahead very straight and rigid without making any propelling movement, but only little stabilizing movements with its fins. The first period lasts several tenths of a second, the second, the straight ahead movement, lasts 5 or 6 seconds. It may then be said that this is the condition under which the fish encounters the resistance of the water, and in which the shaping is effected. It is, therefore, possible to reproduce this state in which the fish is not mis-shapen by himself or actively, but submits passively to the pressure of the fluid. To reproduce this it suffices to draw through the water the experimental body, for instance, by a line passing over two pulleys, at the end of which a weight, which falls, is suspended, and it will also be possible to vary the velocity of movement by varying the weight.

"A first molding of the form of the fish had been recognized before me, and I add nothing to it. It is that shaping by which the forward part grows heavier and enlarges, while, on the other hand, the rear part tapers down. A second molding of the form, that I have discovered, and which consists of repeated inversions, ought to be superposed upon the former, but for the sake of studying it alone it is necessary to separate the one from the other.

"In order to have a body, a model which will be plastic, I take a pliable rubber bag about 20 centimeters long and 4 centimeters wide; and in order to have it equal in mass to the water I fill it with a mixture which I make of oil, vaseline, and white lead, which weighs just as much as water, bulk for bulk. In order to give it velocity I attach it in the water to a line which the fall of a weight is to carry along. Nothing further needs to be done but to watch what takes place when the speed is increased, the bag being closed by simply pressing its opening between two well-united adhesive binders."

At a slight speed the bag, smooth in shape at the

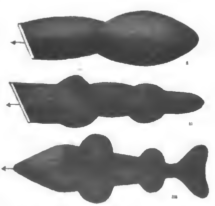

Fig. 1.—Shapes produced by the resistance of water.

To obtain a plastic form as dense as water, a rubber bag is filled with a mixture of oil, vaseline, and white lead. This bag, towed through the water, at a certain speed, assumes the form *I* of two inverted sections. At an increased speed it shows form *II*, five opposing sections. The combination, *III*, of these forms with a shape molded in advance, produces a result decidedly analogous to that of a fish; the fish form differs from this model by the absence of the lower front fin.

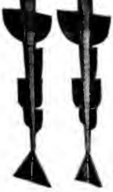

Fig. 2.—These two models of long form have aluminium fins, the front edges of which are turned over and threaded on a steel pin. The rear part of these fins is attached by a rubber band to the wooden body. The fins produce stability by oscillating under the eddying of the water.

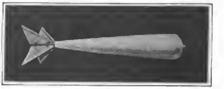

Fig. 4.—Cone-shaped model with vanes at rear end.

A conical model equipped with vanes at the rear end, like those of dirigible balloons, is only stable at low speeds. In this regard, this device is very inferior to fins.

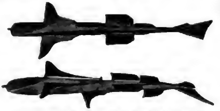

Fig. 3.—Scythe-shaped fins increase stability.

Above, long model of fish in which the pectoral fins only have been hollowed out like a scythe to secure stability at certain speeds. Below, a squaliform model, ballasted dorsally, in which this arrangement has been reproduced, first for the pectorals, then for the first dorsals, and finally for the caudal fin, after which it remains stable when the speed increases.

start, remains unchanged; the transverse waves merely flowing over it, or else turning on its axis. At a sufficient velocity it plainly shows two opposing surfaces, that is, the forward part remains smooth and horizontal, while the rear becomes flattened vertically. If the velocity be further increased, the number of inversions increases, and there can be counted three, five, seven, or more of them, which are alternately horizontal and vertical, the body being inverted in three, five, or seven sections.

The vortices of water fly backward to make room for a moving object which penetrates it. In the presence of the obstacle which the bag opposing itself to their flight forms, they assume an aspect which is repeated in a certain rhythm, it is what is called an oscillation. The oscillation of the water molds the pliable bag which it holds fast, and it is the bag which proves it to us, for the latter is visible and the oscillation is not, Fig. 1—I. It is an evident application of one of the most beautiful theorems of physics discovered by Lord Kelvin on the transformation of a vortex into oscillation in the presence of an obstacle.

However, let us lay aside for a moment these views of advanced theory, and let us place this inverted shape, which we have just examined by itself, upon the one which shows a form with a large and a small end. Let us form upon the body, upon the hull, a shape of two inverted surfaces, flattening the front part (the large end) on top and bottom, and the rear (little end) on the sides (Fig. 1—II). It is the evidence of what has taken place when the velocity was not yet very great. Let us form further on the two preceding models six inverted sections (Fig. 1—III); it is the evidence of what took place when the speed had somewhat increased. But the size of the body has not been affected as to its mass by this last molding; the latter has merely drawn out the surface in sections alternately horizontal and vertical.

The cut (Fig. 1) shows that an object successively shaped in this manner would have a curious resemblance to a typical fish with its inverted body, and its fins alternately horizontal and vertical. But as compared with a fish it would have one fin too many, the lower forward one. In fact, the fish would have assumed this form with scrupulous exactness if it had been homogeneous, that is, if it had the same density in all parts of its body. Such, though, is not the fact, the back is the heaviest part, and it is because of this that dead or tired fish turn up the belly. It is also for this reason that our model does not quite resemble a fish. However, we seem to have obtained the solution more or less in principle; all that is now necessary is to retouch it in certain points. This will be done little by little, and these alterations will also be full of interest.

Before leaving this preliminary survey, let us dwell a little further on one fact. We have said that the multiple inversion was caused by the changing of the whirling of the water into oscillations, and this has reference to the arrangement of the fins with which we have compared it. Inversely, now that the fins exist on the fish, they direct the vortices which fly backward in proportion as the fish advances. "To prove this," says our author, "I took fish of various kinds and passed into their skins silk threads held by a knot and floating freely in the water. When the fish sculls gently the silk threads undulate to its right and left; when, after a good stroke of the tail, it moves quickly forward the silk threads roll themselves around its body, passing between all the fins and outlining between them all two spirals or two screws with inverted thread, characteristic of vortices."

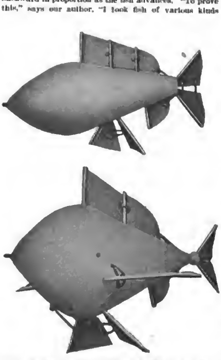
Fig. 5.—Models for studying the stability of flat-sided fish. Upper figure model of a carp; lower a dolphin.

In order to examine the question more closely, it is now necessary to look at it from another side. If it is really true that the water has molded the fish, it must have made of it a shape of minimum resistance, for, so far as this result had not already been attained the water took hold to mold and efface, and its action is carried on until it has the least influence possible, corresponding to a minimum of resistance. An attempt can be made to prove this.

"I took," continues our investigator in discussing the subject, "six models of the same length and diameter, and having the following forms: form of a fish; a cone with apex to the rear; a cone with apex to the front; a double-pointed spindle; and a spindle with its ends flattened in mutually perpendicular planes, and a body bounded by a discontinuous surface of two sections joined at the middle. Each model was built in three lengths: small, medium, and long. In all eighteen models were tested at speeds increasing from 50 centimeters to 7 meters 50 centimeters a second. The models were drawn with a line operated by a falling weight, and were carefully timed by a chronometer. They gave eighteen curves of motion, which have been carefully compared, and the result showed the fish was by no means the best. It only came in third, the first place being held by the cone with the large end forward. Moreover, it was impossible to determine which of the forms, short, medium, or long, was the best.

The result as regards a fish-body is decidedly important. First of all, from a practical point of view, it condemns in advance any attempt to make the envelope of a balloon, or the hull of a submarine or of a torpedo, a direct and unchanged copy of the body of a fish, even of a swift one. The imitation should be more complete and exact. Then, from the theoretical point of view, this result teaches us that to conduct our investigation successfully the question to be considered is not one of taking a part of the fish while neglecting the rest; for instance, the body, while forgetting the fins, but that it is necessary to take the whole, body and fins, since in fact the water has molded all and did not stop so long as there was anything to do.

"Through the knowledge of these facts and through reflection the writer was led from the problem of velocity to that of stability, which is by no means less important. All these plain forms advanced at the end of their line with complicated oscillations which fish never make; they are absolutely stable. He then thought that his models would also become stable if he succeeded in imitating on them the play of the fins. The artificial fins were simply small thin plates of aluminium pivoted on a steel pin and attached to the model at their rear side by means of rubber elastic.

Fins were fitted on the three most interesting models in the three lengths, that is, on the model with the dis-

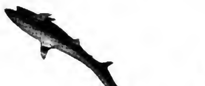
Fig. 6.—The thresher, one of the fastest swimmers of the shark family.

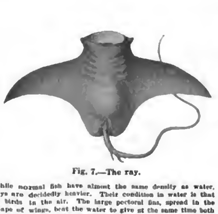
Fig. 7.—The ray.

While normal fish have almost the same density as water, rays are decidedly heavier. Their condition in water is that of birds in the air. The large pectoral fins, spread in the shape of wings, beat the water to give at the same time both support and forward movement. The tail, the propelling organ in other fish, is here only a "reminiscent" organ; it regresses, and drags useless in the water which tapers it down.

Fig. 8.—Another deep-sea monster. This fish is a sluggish swimmer, and awaits in its retreat for its prey, some weaker fish, to swim by, when it opens its huge jaws, and its victim is drawn in by the strong current induced.

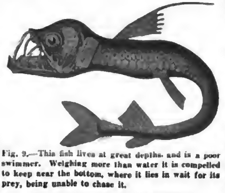
Fig. 9.—This fish lives at great depths and is a poor swimmer. Weighing more than water it is compelled to keep near the bottom, where it lies in wait for its prey, being unable to chase it.

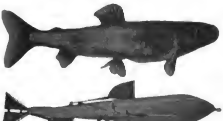
Fig. 10.—Trout and artificial model with one dorsal fin. This shape, weighted dorsally, is adapted to great speeds, but its stability is uncertain, as it requires a definite tension of each fin at each speed. In this model it was proved that the paired fins, widely extended at low speeds, become progressively relaxed as the velocity increases.

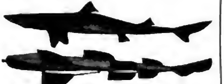
Fig. 11.—Neutral shark and squaliform model. Like the natural fish, the model has the back heavier than the belly. Neither, however, capsizes in swimming owing to the suitable tension of the fins, which always remain spread, and to the form of the tail, which is heterocercal, that is, having two unequal lobes.

continuous surfaces, on the fish, and on the cone with the large end forward. Thanks to the fins, which oscillated under the eddying of the water, these nine models became entirely stable, and moved absolutely straight ahead at nearly every velocity. Only at certain velocities was there rotation around the axis, a simple irregularity which he did not know how to correct until later, as he tells us further on.

The results of this new investigation were the following: In each form of model it is always the shortest length which is the best; then comes the medium length; and lastly, the long one. On the other hand, among the forms of the same length, the classing is always the following: 1, fish; 2, cone; 3, model with the mutually perpendicular plates.

So when the fish is taken as a whole, and what nature has produced is imitated down to the details the speediest and most stable form is obtained. The cone having lost the first place, it may be objected that stabilization by fins does not suit it, and that it would be better, for instance, to give it a caudal vaning, like the feathering at the end of an arrow, such as is used for balloons. Our author tried this experiment. The cone with the vaned tail (Fig. 4), did not travel well except at low speeds, after which it turned constantly and violently around its axis. The caudal vaning is, therefore, inferior to fins.

Will we be able to develop our aerial and aquatic machines so far as to make use of a stabilizing device analogous to fins, which will cut and direct in vortices the eddies of the resisting medium? Monsieur Houssay is convinced that the thing is possible. The inclined planes or redans arranged under the bottom of aerial boats with screws are already a slight but evident indication of the benefit which could be obtained by it (for a further discussion of this point see *La Science et la Vie*, May, 1914, p. 291).

However, nature has many fish to show which seem to be very fair swimmers, and which are much more flattened on the side than the models examined up to now. Our author wished to study the conditions of their movement and he made two models (Fig. 5), the one, in the form of a carp, very slightly flattened, the other shaped as a dolphin, which is much more compressed. While the earlier models nearly always traveled well, except at certain speeds, he had the greatest difficulty in making these latter ones run straight. In the end, after much experimenting, he found that the rubber bands attaching the ventral fins ought to have more or less tension according to the velocity. To obtain this result he connected the rubber bands to a line attached to a screw set in the body, and by turning this screw in one direction or the other the rubber bands were stretched or relaxed.

For low speed the rubbers should be loose; while at a certain higher speed it was necessary to have considerable tension. Everything went well for some time when, all at once, the speed increasing the rubber had to be entirely slack; and after a further interval he was obliged to stretch it as previously. Consequently, two tensions are necessary, a slight one and a strong one which are successive as the speed increases. The action of fish is not at all like this. Their paired fins, which at high speeds are completely closed or suppressed along the body, are successively unfolded and stretched more and more as the speed diminishes. This difference raises a remarkable problem, of which our author soon gives the solution by showing that it depends on the position of the center of gravity.

"In examining the velocity of these last models," he states, "I found their result very inferior to that of the preceding models. We have already noticed that the extremely long models do not travel as well as the short ones; now notice that the flattened models do not travel as well as the roundish ones, and this is why, at the beginning, I called fish which are too long or too flat mis-shapen or ill-made.

"Still, the study of these models has taught us something very curious and very important: this is the possibility of securing stability by stretching or relaxing the attachment of the fins. If I had known this when investigating my rounded models I might have been able to prevent their turning at the few velocities in which this phenomenon appeared. I, therefore, took them once more; and fastened the end of the rubber tension bands to screws which I could tighten and relax.

"By stretching the rubbers very slightly I was easily able to suppress the rotation in the short fish-model. I did not succeed in doing this in the longer fish, excepting at tensions greater than a natural fish would have been able to produce with his muscles. It then occurred to me to hollow out the pectoral fins in the shape of a scythe, and when this was done a very slight tension sufficed. This new result was very useful to me in assuring the stability of more complicated models at increasing velocities."

Excepting the short cone, which was always stabilized by its fins, it was not possible by any means to suppress the rotation around the axis in the cones of medium and long lengths. This indicates a further superiority in the keel-fish which, quicker in movement, can be easily stabilized under any conditions. At this stage the problem seemed to be almost solved; however, there were great and persistent difficulties. The models, which we have just studied, do they agree satisfactorily with the three qualities which we know are essential to obtain a fish: swiftness, plasticity, equal density, and how do they agree with these?

As regards swiftness, nothing is changed; they are, under the conditions of the first experiments, comparable to the swimming straight ahead of fish. The models are plastic and can be changed in shape, but the plasticity is localized in the oscillating and elastic fins. Each of them, therefore, corresponds to a given fish at a given velocity, the body of which fish, at a minimum of resistance, is no longer molded beyond a certain shaping down. The diversity of forms studied represents the variation of the shaping down. Lastly, the models were made of equal density with the water, and for this, as they were of wood, and to insure their proper floating, they were ballasted just enough to keep them under water without sinking. This ballast was put in the belly and naturally it contributed its share to the stability. This condition is not at all that of the fish, in which the back is heavier than the belly. The ballast should have been on the back, but in such case how could the models be made to maintain its proper position? This is the real pith of the matter, but how to reach it.

"The question was very difficult," says our author. "Let us, first of all, recapitulate the differences which persist between our models and natural fish: First, ventral ballast instead of dorsal ballast; second, the fins in pairs, pectoral, and ventral, are on the lateral line, that is, at the center of the side instead of being at the ventral edge; third, play of the fins, tension and relaxation, not in agreement with that of fish.

"I, therefore, remade my models by putting the ballast toward the back, and in such manner that they capsize immediately. I lowered the pairs of fins to the ventral edge of the body, but I left the tail as it was before, that is, with two equal lobes, homocercal, as zoologists say.

"I had hundreds of setbacks; my model did not capsize once for all, as might have been feared, but it rotated constantly on its axis. It then occurred to me to make the tail heterocercal, that is, with a large upper lobe and a small lower lobe. This was what was needed, nothing else, and my failures were transformed into definite successes. My model had become all at once equal to a natural shark, and moved along exactly like a shark."

The correct action of this moving body demanded very exact tensions of the fins. The ventral fins needed the same tension for all velocities, and there were no difficulties on this account; but the pectoral fins had to be regulated exactly for each velocity. At low velocities this regulation could be easily made on the model with rounded fins. In proportion as the speed increased the scientist was obliged, after numerous experiments, to scoop out the pectoral fins in the shape of a scythe, then to hollow in the same way the first dorsal fin, then lastly the upper lobe of the caudal fin. He thus obtained the whole series of natural forms of the squalidae with the exact conditions of speed to which each one corresponded.

The sciences of comparative anatomy and paleontology have taught us that this squaliform shape is the most primitive and the most ancient, and our author succeeded in reproducing it exactly, with the exact play of its fins more or less stretched, but always open and spread out, never closed or suppressed.

He also desired to reproduce artificially the conditions in which those fish exist which have appeared more recently in the waters on the surface of the globe, and he remade his models of carp, of dolphin, and of roundish fish with two dorsal fins, which are very good for low velocities, and the models of roundish fish with a single dorsal fin, the best shape for great velocities. All these he remade with a dorsal ballast and with fins lowered to the ventral edge.

The problem constantly grew more difficult, for it was necessary to find a correct tension for each velocity in these models, not merely for the pectorals, but also for the ventral fins, and at times for the first dorsal. After repeated experiments he always reached the goal, and, taken altogether, the action of these various fins can be summed up thus; extreme tension of the pectoral and ventral fins for low velocities, progressive relaxation proportioned to the increase of speed, complete suppression of movement at very great velocities. This agrees exactly with the actions of natural fish, and we have reached this precise result by having recourse again to the condition of the dorsal center of gravity.

"Now that we have exactly reproduced all the principal kinds of fish by determining solely the conditions of the least resistance and of stability in the water," says the author in his summing up, "we can stop, for it is impossible for me to expound in a short article the investigations I have made as regards the shape and position of the mid-frame; those relative to the conditions that have changed the heterocercal tail of ancient fish into the homocercal tail of more recent fish; relative to the displacement of the ventral line toward the head in proportion as the vertebral column becomes more and more bony in the course of geologic ages; relative to the particular transformation of the fins and to the deformations of the body in cases where speed of movement is lost; relative to the improvement in shape of fish formerly slow, which have become very swift, as the eel and mackerel, the fins of which have been recast in a very special manner. I merely mention these details selected from many others, to show that these new methods of zoological investigation can, if we start from a well-defined point and have a clear conception of what is needed, lead to the explanation of all the combinations of parts and of all the details."

In conclusion let us take a hasty view of the indications from which engineers might profit in improving the speed and, above all, the stability of submarines, submersibles, torpedoes, dirigible balloons, etc., in those cases where the latter have a weak power of ascension, and so far as they can be considered as evidently equal in density to the air. In the first place, as has already been said, it is useless to limit oneself to copying body for body, the result would be inferior to that which is already in common use. What is necessary is, to reach the point of placing oscillating fins on the keels under the simplest conditions.

The fact that fish draw in their paired fins at very great speeds is not an opposing indication: first, because they always keep open their single fins, and further, because they cannot close the paired fins excepting at velocities which, on account of human limitations, large engines, such as balloons and submarines, can never equal, and, lastly, because this closing is only obtained by aid of small exact changes of form which result from the dorsal position of the center of gravity.

Now it would be absurd to desire to imitate this condition which, for a slight improvement in speed, would give an extremely precarious stability. No one dreams, for instance, of putting the car above the balloon. Therefore, neither is it necessary to imitate those conditions which are connected with this.

If we leave the center of gravity fairly low, which is certainly the best thing to do, we return, not to the exact condition of fish, which it is well to avoid copying too servilely, but to the approximate conditions of our author's first models ballasted ventrally. The paired fins ought in this case to be placed in the center of the side and not at the ventral edge. Above all, an important point in practice, they can be stretched once for all for nearly all velocities, and it would not be necessary to touch them again except to change the direction. Moreover, the direction could be easily obtained without touching them by preserving the present rudders, which would serve nothing but this purpose, and, above all, would correct the lurchings, the rollings and pitchings being totally suppressed.

For the rare critical speeds, where the ordinary tension of the fins would not be sufficient, if such should be attained, it would be very simple to change the tension since there could be but two tensions possible with no intermediary between them. For these velocities it would suffice to bend the attaching spring (replacing the rubber) an amount known in advance, and which could be found without awkward fumbling.

It is clearly evident that all our heavily ballasted engines can move without stabilizing and oscillating fins; the proof is that they do it. But with these fins and under the conditions mentioned they would have an indestructible stability, and could advance straight ahead with all the speed that the powerful motors of the present day would give them. Besides, there would be nothing to prevent putting of the car sufficiently far from the envelope of a balloon to avoid explosions. It would suffice to make the car a second fish sailing in company with the former and below it. Our author is convinced that under these conditions of absolute stability the velocity could be increased to a considerable degree.

Casino at Interlaken

A SUCCESSFUL reinforced concrete construction is the new Casino of Interlaken, and this handsome building abundantly proves that this method does not exclude great architectural ornament. It is constructed on the Hennebique system, and has a main hall with stage at one end and seating room for 600 persons, also other accommodations in the way of restaurant, etc. The hall has a roof of 42 feet width made up of reinforced concrete cross-members to which is suspended a reinforced plaster vaulting, with appropriate relief ornamentation.

Ideals in City Planning*

Improvement and Operation of Cities a Work for Trained Experts

By Harrington Emerson

Two years ago I was in Tacoma, which has naturally one of the beautiful locations in the world. The glory of Tacoma is its Point Defiance Park, high above and surrounded on three sides by the wonderful waters of Puget Sound. At flowing or ebbing tide the waters rush swirling with a power that suggests the rapids of Niagara. Trees several centuries old grow in the park, gigantic cedars and fir and hemlock. Yet I heard two citizens of Tacoma advocating the donation of the wonderful park to the United States as grounds for a penitentiary. "We don't care for old trees and fine views," said one, "we want to sell tobacco to the soldier guards." Happily this desecration was not permitted.

Real beauty costs little. The most beautiful things in all the universe are absolutely free, the stars, the color of the sunset clouds, the hoar-frost on the trees, the breaking of waves on a shore, the budding of the trees and the blooming of the flowers in spring; and so with the cities, the most beautiful places I know in the world have not been made so by lavish expense but by intelligent care. On the other hand, the value of beauty is so great that men and women are willing to spend immense sums for the gain.

Let us pass on from beauty to health.

Without vouching for their accuracy, I quote the following list from the Census Bureau Report for 1911:

MORTALITY STATISTICS.	Per 1,000.
Seattle	8.8
Cleveland	13.8
San Francisco	15.2
Denver	15.5
Washington	18.7
Chicago	14.5
Baltimore	18.4
Boston	17.1
Los Angeles	14.5
St. Paul	10.9
Duluth	11.7
Kansas City	15.4
St. Louis	15.4
Buffalo	14.5
New York	15.2
Cincinnati	16.5
Philadelphia	16.6
Pittsburgh	14.9
Milwaukee	11.9

There is the city of Seattle whose death rate is only 8.8 or 36 per cent better than Cleveland. There will be the natural instinct to make excuses, to assume that Seattle is more favorably located, to deny to the intelligence and conscious effort this wonderful record of Seattle. Some will maintain that Seattle, being further north and on salt water, ought to have a better record. Let us see whether it is location or intelligence. London, England, is further north than Seattle, is on salt water and has a similar climate to Seattle, but in 1736 the births in London were 16,491, the deaths 27,581.

Seattle is a younger city than Cleveland, there are fewer old people, more inhabitants in the prime of life, therefore the low death rate. This is granted, but the real test comes when we check the deaths of children under five years old. Seattle's rate is the lowest in the world. The 1911 Census Bureau report gives Cleveland's deaths under five years of age as 31.3 per cent of the total, and Seattle's as 18.4 per cent of the total.

Forty years ago, in Munich, Bavaria, the death rate approached 40 per cent of births for children under one year of age; in Seattle the record is under 10 per cent for children under five years of age. The Seattle rate in fact approaches 8 per cent.[1] In this matter of life and death I hold up Seattle as an example of what can be attained by knowledge, faith, courage and power.

A city consists of people and also of buildings. The word health, in a large sense, applies to the conservation of property from fire. How does Cleveland stand in this respect? There are good sized cities in the world whose fire loss, owing to excellent preventative measures, is only $0.04 per inhabitant per annum. Cleveland's loss is reported at $2.43[2] or 60 times greater than that of one of the Swiss cities, and this does not take into account the loss of business due to fires, nor the cost of fire departments, which are palliatives, not remedies.

In a fourteen years' residence in various European cities, I saw only three fires. We excel in the work of fire extinguishment but what we want is fire prevention, and our studies and the experience of other great world cities show that the fire loss ought to be reduced to about $0.24 per inhabitant.

The best civic virtue is intelligence. What is a man of first class intelligence and training worth compared to the average man? Why are Denmark, Norway and Sweden rich and Nicaragua, Honduras, San Salvador, Guatamala poor? Why have property values doubled in the Philippines in the last fifteen years? In our special work of human efficiency, we have in many cases found no difficulty in bringing up the average efficiency of a thousand men from 50 per cent to 100 per cent without discharging or harrying any of them.

Remember that I am not putting up any task that has not already been attained elsewhere. Human intelligence is without limit and there is always more ahead than there is behind.

The next fundamental is morality, reliability.

It is far easier to build up the morality of a city than the morality of individuals. A certain number of people are born wicked but even they are wicked only a small part of the time, and in a model city even these people would either behave, leave, or be controlled.

The next and last fundamental is industry.

If assessments both real and personal were on the same basis everywhere in the United States, they would be comparative. The average valuation per inhabitant or per voter or per adult above the age of 18 might be used. Assessed valuation is an indication of relative standing, savings bank deposits are an indication, bank clearings are an indication, the per capita amounts of internal revenue tax paid for intoxicants and tobacco are negative indications.

It is difficult to give beauty, health, intelligence, morality, industry a money value, but would it be worth one dollar a day per inhabitant to excel in all these respects? The yearly gain, for a city the size of Cleveland, would be $21,900,000 at $0.10 a day in one year, or at a dollar a day a piece it would be $219,000,000.

That you may not feel that I have overdrawn the possibilities, I shall give you the description of two communities, one British and one German.

The island of Bermuda is 700 miles from anywhere, out of the path of all steam lines except those from Halifax to the West Indies. The island has only 20 square miles of area of which 3,000 acres are under cultivation. The island has 20,000 inhabitants, two thirds colored. The island in its roads, as well as its natural scenery, is a dream of beauty, no more beautiful place in all the world. Its healthfulness is very high, its intelligence unusual, no illiteracy, its morality so great that there is practically no crime of any kind, and its industry such that it supports without poverty 1,000 people per square mile, 1½ to the acre.

Ohio has coal mines, lies between the great lakes and the Ohio River; is the great central State between the East and West, is altogether one of the best States in the whole Union; but if Ohio had the same relative population as Bermuda, it would have 40,000,000 inhabitants.

As my second example, I shall quote from *The New Statesman's* review of Frederick C. Howe's book "European Cities at Work."

"Most people know nowadays that it is to Germany—that paradox of one of the best educated, most enlightened and up-to-date peoples of the world, yet still, for the great part, under the thraldom of a semi-despotic monarch and an uncurbed squirearchy—that we must look for the most striking examples of state socialism; but Mr. Howe's book will be a revelation to most readers as to the development and progress of the German cities.

"Germany almost alone among the civilized nations sees the city as the permanent center of the civilization of the future, and Germany almost alone is building her cities to make them contribute to the happiness, health, and well-being of the people. This seems to be the primary consideration with officials and citizens.

"Writing of Dusseldorf as a typical example, Mr. Howe states that the German city aims at being a model employer. This town treats its five thousand clerks and workmen more generously than private companies, and goes beyond the requirements of the law in regard to sickness, accident, and old age insurance. It grants all workmen and employees a retiring allowance, as well as pensions for widows and orphans. The wages paid rise with the years of service, and the conditions of work are determined by municipal regulations. This city goes in for all sorts of municipal trading. The whole city has been as much planned out as a garden city as Letchworth, and is one of the finest towns in the world. The city owns a considerable portion of the land on which it stands, some 2,500 acres belonging to it, and it has set aside a special fund of over $5,000,000 as working capital with which to buy and sell real estate, while its powers of expropriation and its taxes on increment values make Mr. Lloyd George's schemes appear reactionary. The city owns the trams, gas, electricity, and water works. It operates a municipal mortgage bank, which has already advanced considerably over $5,000,000 to people of small means for the purchase of their homes. It has built houses for its own work-people, a home for unmarried people; it has one or two municipal restaurants, carries on a wine business, a savings bank, a municipal pawnshop, also a legal aid department, where advice is furnished free. It maintains a corps of eighteen physicians to give gratuitous service to needy persons, while it has numerous municipal hospitals, infirmaries, sanatoria, and nursing homes, as well as an academy of practical medicine attached to the principal hospital. It owns and maintains a fine theater as well as a great concert hall, it supports a symphony orchestra of sixty-one players, and provides musical direction. It also maintains a fine arts gallery, a museum of natural science and history, and a zoological garden, all of these agencies being correlated with the educational system. A few years ago the city invested something over three-quarters of a million sterling in the shares of an industrial undertaking of a profitable nature identified with the city. As might be imagined, its indebtedness is large, being in the neighborhood of $80,000,000, but no less than 87.3 per cent of this is placed in industrial undertaking, and against this indebtedness the city possesses assets exceeding $50,000,000 in value.

Although so much space has here been devoted to Dusseldorf, it must not be thought that the city is unique in the diversity of its municipal undertakings or the success with which they are administered. Mr. Howe's book shows us that in these respects it is characteristic of all large German cities.

"The German city is free to own almost anything, free to control the individual and his property, free to borrow, free to experiment, free to develop as it wills. Its bonds to the state rest so lightly that it is almost unconscious of its chains. The citizen is a subject of the city, just as he is a subject of the state and empire.

"Under the laws of the state the German city can do anything it is not expressly forbidden to do, or that the central administrative authorities do not forbid. Generally speaking it can do anything an individual can do."

The German city is the justification of the expert, for it is governed by experts who devote their lives to that profession.

"Men prepare themselves for city administration as they do for the law, medicine, or any other profession. They take special courses in the universities or technical schools in law, finances, engineering, town planning, education, or sanitation. On graduation they compete for a municipal post along with other candidates. Sometimes they enter the permanent service from the city council or the state civil administration, or the profession of law. They rise from one position to another or pass from city to city much as a clergyman or professor in this country moves from place to place. In time they hope to become burgomaster, and if they make a success in their city their reputation is known all over Germany. This is true of the burgomaster, of members of the magistrate or administrative council, and of the important permanent officials generally. . . .

"In salary, in social position, in power and opportunity, as well as in permanency of tenure, Germany has provided a system that attracts men of talent and ability to city administration. . . .

"The business men who rule the German city are not the small shopkeepers, as in Great Britain; they are the bankers, merchants, real estate speculators, and professional men. They form the ruling class. They elect the council which in turn elects the burgomaster and members of the magistrat. . . .

"Despite the political power of the business men, they do not legislate in the interest of their class, as they do in America. That is one of the anomalies of Germany, for I know of no other country in the world in which this is true" . . .

Civil service is a delusion. Tenure of office does not make citizens either beautiful, healthy, intelligent, moral or industrious. It may have exactly the opposite effect, it perpetuates incompetency. Some of the most inefficient employees I have ever saw were the civil service incumbents in Washington. Among many of them it is not good form to be either intelligent or industrious.

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*Abstracts from an address delivered before the Civic League of Cleveland, February 28th, 1914.

[1] Deaths of infants under 1 year, per 1,000 births, 1910—Seattle, 82; Cleveland, 150. (Census Bureau.)

[2] National Board of Fire Underwriters' Report for 1912.

A commission form of government? This may be a distinct step backward. An honest, competent commission may be better than a dishonest mayor and incompetent board of aldermen, but to substitute a collective executive for an individual executive is to weaken one of the fundamental principles of organization, namely, localized responsibility and authority.

The best form of organization in the world is found in modern marine service, and next to that is a great modern office building, which is probably evolving the future city type. The administration of a great office building, like that of a great ship, is simple and successful because there are a few definite aims and ideals and everything else is made subservient to them. In both cases, we have a competent head of the line, with full responsibility. He is surrounded by a staff; he could not for an hour perform his duties without staff help, and the staff and line together carry out the work.

Line gives the skeleton of administration and authority. Staff gives universal knowledge. Line without staff never has sufficient knowledge. Staff without line never has organization. Staff corresponds to a dictionary, line corresponds to grammar. The practical difficulty with unstandardized men is that the line thinks it has knowledge and the staff thinks it has authority.

Therefore the three practical requirements for good city government are:

High Ideals,
Reasonable Standards,
Their Attainment

through a strong administration of line and staff.

Acoustics of Auditoriums—II*

An Investigation of the Acoustical Properties of the Auditorium of the University of Illinois

By Prof. F. R. Watson

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2031, Page 359, December 5, 1914

IV. THE INVESTIGATIONS IN THE AUDITORIUM AT THE UNIVERSITY OF ILLINOIS.

A. PRELIMINARY WORK.

As already stated a chaos of sound was set up when an observer in the Auditorium spoke or shouted or clapped his hands. Both echoes and reverberations were present and could be heard in all parts of the room, though the echoes seemed to be strongest on the stage and in the balcony. The prospects for bettering the acoustics were not very encouraging. Luckily, the cure for reverberation was fairly simple, since Sabine's method gave a definite procedure that could be applied to this case. The cure for the echo, however, was yet to be found. It was first necessary to find out which walls set up the defect.

The attempt to locate echoes by generating a sound and listening with the ear met with only partial success. The ear is sensitive enough but becomes confused when many echoes are present, coming apparently from every direction, so that the evidence thus obtained is not altogether conclusive. It became apparent that the successful solution lay in fixing the attention on the sound going in a particular direction and finding out where it went after reflection; then tracing out the path in another particular direction, and so on until the evidence obtained gave some hint of the general action of the sound.

The first step in the application of this principle was to use a faint sound which could not be heard at any great distance unless reinforced in some way. The ticks of a watch were directed, by means of a reflector (Fig. 2) to certain walls suspected of giving echoes. Using the relation that the angle of incidence equals the angle of reflection, the reflected sound was readily located, and the watch ticks heard distinctly after they had traveled a total distance as great as 70 to 80 feet from the source.

In a later experiment, a metronome was used which gave a louder sound. It was enclosed in a sound-proof

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*Abstract of Bulletin 73, of the Engineering Experiment Station. Published by the University of Illinois.

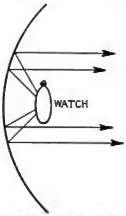

Fig. 2.—Watch as source of sound, backed by concave reflector.

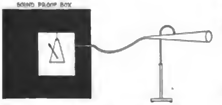

Fig. 3.—Metronome as source of sound.

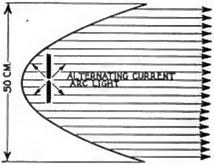

Fig. 4.—Arc light as source of sound.

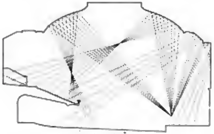

Fig. 5.—Longitudinal section of auditorium, showing the chief concentration of sound, the diffraction effects being disregarded.

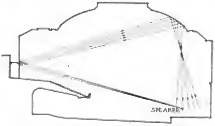

Fig. 6.—Longitudinal section, showing how sound is returned to the stage to form an echo.

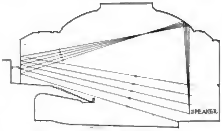

Fig. 7.—Longitudinal section showing formation of echo on the stage.

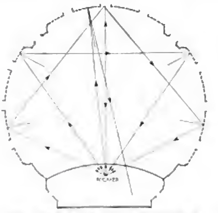

Fig. 8.—Plan of auditorium, showing action of rear wall on the sound.

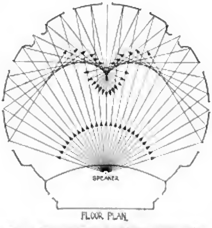

Fig. 9.—Plan of auditorium, showing concentration of sound by the rear wall.

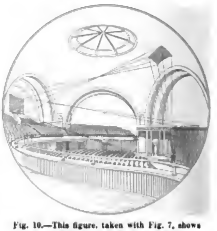

Fig. 10.—This figure, taken with Fig. 7, shows how an echo is set up on the stage.

structure (Fig. 3) with only one opening, so that the sound could be directed by means of horn. This method was suggested by the work of Gustav Lyon in the Hall of the Trocadero at Paris,[13] where a somewhat similar arrangement was used. The method was successful and verified the observations taken previously.

Though the results obtained with the watch and metronome seemed conclusive, yet the observer was not always confident of the results. A further method was sought, and a more satisfactory one found by using an alternating current arc-light at the focus of a parabolic reflector (Fig. 4). In addition to the light, the arc gave forth a hissing sound, which was of short wave length and therefore experienced but little diffraction. The bundle of light rays was, therefore, accompanied by a bundle of sound, both coming from the same source and subject to the same law of reflection. The path of the sound was easily found by noting the position of the spot of light on the wall. The reflected sound was located by applying the relation that the angles of incidence and reflection are equal. The arc-light sound was intense and gave the observer confidence in results that was lacking in the other methods. To trace successive reflections, small mirrors were fastened to the reflecting walls so that the path of the reflected sound was indicated by the reflected light. A "diagnosis" of the acoustical troubles of the Auditorium was then made by this method.

It should be noted here that the arc-light sound is not the same as the sounds of music or speech, these latter ones being of lower pitch and of longer wave length. It was, therefore, a matter of doubt whether the results obtained would hold also for the case of speech or music. Tests made by observers stationed in the Auditorium when musical numbers and speeches were rendered, however, verified the general conclusions obtained with the arc-light.

It should be pointed out in this connection that there is an objection to applying the "ray" method of geometrical optics to the case of sound. It is much more difficult to get a ray of sound than it is to get a ray of light.[14] This is due to the difference in the wave lengths in the two cases. It appears that the waves are diffracted, or spread out, in proportion to their length, the longer waves being spread out to a greater extent. The short waves of light from the sun, for instance, as they come through a window mark out a sharp pattern on the floor, which shows that the waves proceed in straight lines with but little diffraction or spreading. Far different is it with the longer waves of sound. If the window is open, we are able to hear practically all the sounds from outdoors, even that of a wagon around the corner, although we may be at the other end of the room away from the window. The longer sound waves spread out and bend at right angles around corners, so that it is almost impossible to get a sound shadow with them. Furthermore, in the matter of reflection, it appears that the area of the reflecting wall must be comparable with the length of the waves being deflected. In the case of light, the waves are very minute, hence a mirror can be very small and yet be able to set up a reflection; but sound waves are of greater length, the average wave length of speech (45 cm.) being about 700,000 times longer than the wave length of yellow light (.00006 cm.), hence the reflecting surface must be correspondingly larger. An illustration will perhaps make this clearer. Suppose a post one foot square projects through a water surface. The small ripples on the water will be reflected easily from the post, but the larger water waves pass by almost as if the post were not there. The reflecting surface must have an area comparable with the size of the wave if it is to cause an effective reflection. Relief work in auditoriums, if of small dimensions, will affect only the high pitched sounds, i. e., those of short wave length, while the low pitched sounds of wave length are reflected much the same as from a rather rough wall. It is also shown that the area of the reflecting surface is dependent on its distance from the source of sound and from the observer; the greater these distances are the larger must be the reflecting surface.[15]

These considerations all show that the reflection of sound is a complicated matter. The dimensions of a wall to reflect sound, or of relief work to scatter it, are determined by the wave length and by the various other factors mentioned. It should be said with caution that a "ray" of sound is reflected in a definite way from a small bit of relief work. We must deal with *bundles* of sound, not too sharply bounded, and have them strike surfaces of considerable area in order to produce reflections with any completeness.

II. DETAILS OF THE ACOUSTICAL SURVEY IN THE AUDITORIUM.

The general effect of the walls of the Auditorium on the sound may be anticipated by considering analogous cases in geometrical optics, but with the restrictions on "rays" described in the preceding paragraph. The sound does not actually confine itself to the sharp boundaries shown. The diagrams are intended to indicate the main effect of the sound in the region so bounded. Fig. 5 gives such an idea for the concentration of sound in the longitudinal section of the Auditorium.

The plan followed in the experimental work was to anticipate the path of the sound as indicated in Fig. 5, then to verify the results with the arc-light reflector. Figs. 6 and 7 show the effect of the rear wall in the balcony in forming echoes on the stage. The speaker was particularly unfortunate, being afflicted with no less than ten echoes.

The hard, smooth, circular wall bounding the main floor under the balcony gave echoes as shown in Fig. 8, the sound going also in the reverse direction of the arrows.

A more comprehensive idea of the action of this wall is shown in Fig. 9. This reflected sound was small in amount and therefore not a serious disadvantage.

The cases cited were fairly easy to determine since the bundles of sound considered were confined closely to either a vertical or a horizontal plane for which the plans of the building gave some idea of the probable path of the sound. For other planes, the paths followed could be anticipated by analogy from the results already found. Fig. 10 shows in perspective the development of the result expressed in Fig. 7.

A square bundle of sound starts from the stage and strikes the spherical surface of the dome. After reflection, it is brought to a point focus, as shown, and spreads out until it strikes the vertical cylindrical wall in the rear of the balcony. This wall reflects it to a line focus after which it proceeds to the stage. Auditors on all parts of the stage complained of hearing echoes.

Referring to Fig. 5, it is seen that the arch over the stage reflects sound back to the stage. Fig. 11 shows in perspective the focusing action of this overhead arch. Fig. 12 shows the effect of the second arch. Some of this sound is reflected to the stage and to the seats in front of the stage; other portions, striking more nearly horizontally, are reflected to the side balconies. The echoes

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[13] La Nature (Paris), April 24, 1909.

[14] Rayleigh "Theory of Sound," Vol. II, 282.

[15] Rayleigh, Ibid. 283.

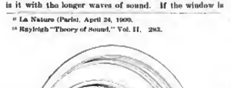


Fig. 11.—Perspective of stage, showing focusing action of arch on sound.

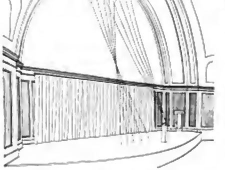


Fig. 16.—Hard plaster reflector and pulpit.

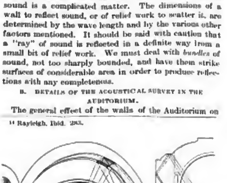


Fig. 12.—Perspective of stage, showing focusing action of second arch.

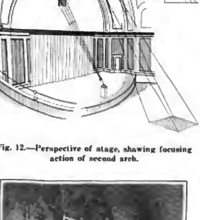


Fig. 18.—Large parabolic reflector.

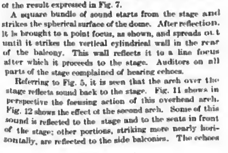


Fig. 13.—Transverse section of auditorium, showing how most pronounced echoes are set up by the two concave surfaces.

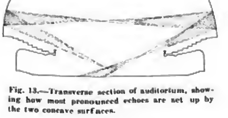


Fig. 17.—Parabolic reflector, showing its action on sound.

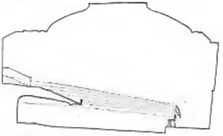


Fig. 19.—Canvases hung to eliminate echoes.

are not strong except for high pitched notes with short wave lengths, since the width of the arch is small.

Passing now to the transverse section, Fig. 13, we find the most pronounced echoes in the Auditorium. If an observer generates a sound in the middle of the room directly under the center of the skylight, distinct echoes are set up. A bundle of sound passes to the concave surface which converges the sound to a focus, after which it spreads out again to the other concave surface and is again converged to a focus nearly at the starting point. The distance traveled is about 22½ feet, taking about ¼ second, so that the conditions are right for setting up a strong echo. This echo is duplicated by the sound which goes in the reverse of the path just described. Another echo, somewhat less strong, is formed by the sound that goes to the dome overhead and which is reflected almost straight back, since the observer is nearly at the center of the sphere of which the dome is a part. These echoes repeat themselves, for the sound does not stop on reaching the starting point but is reflected from the floor and repeats the action just described. As many as ten distinct echoes have been generated by a single impulse of sound.

The echo shown in Fig. 13 is repeated in a somewhat modified form for a sound generated on the stage by a speaker. Fig. 14 shows the path taken by the sound. This echo is duplicated by the sound that goes in the reverse direction of the arrows, so the speaker is greeted from both sides. The sound does not confine itself closely to a geometrical pattern, as shown in the picture, but spreads out by diffraction. The main effect is shown by the figure.

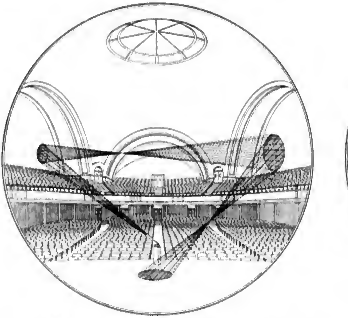


Fig. 14.—Perspective showing how an echo is formed on the stage by two reflections. Diffraction effects are not considered in the drawing.

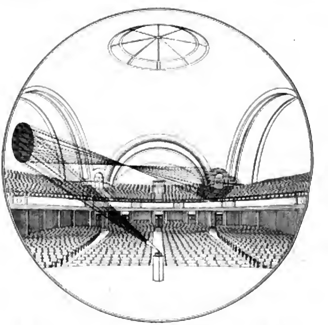


Fig. 15.—Perspective showing sound reflected from concave wall in balcony. Diffraction not considered.

Thus far only the echoes that reached the stage have been described. Other echoes were found in other parts of the hall, and it seemed that few places were free from them. The side walls in the balcony, for instance, were instrumental in causing strong echoes in the rear of the balcony. Fig. 15 shows in perspective the action of one of these walls. These two surfaces were similar in shape and symmetrically placed. Each was the upper portion of a concave surface with its center of curvature in the center of the building under the dome. The general effect of the left hand wall was to concentrate the sound falling on it in the right hand seats in the balcony. Some of the sound struck the opposite wall and was reflected to the stage, as shown in Fig. 14. Auditors who sought the furthermost rear seats in the balcony to escape echoes were thus caught by this unexpected action of the sound. The right hand wall acted in a similar way to send the sound to the upper left balcony.

The dome surface concentrates most of its sound near the front of the central portion of the balcony and the ground floor in front of the balcony in the form of a caustic cone. Figs. 5, 6, and 7 give some conception of how a concentration of sound is caused by this spherical surface. The echo in the front portion of the balcony was especially distinct. On one occasion, in this place, the author was able to hear the speaker more clearly from the echo than by listening to the direct sound.

Minor echoes were set up by the horizontal arch surfaces in the balcony. The sound from the stage was concentrated by reflection from those surfaces and then passed to a second reflection from the concave surfaces back of them. Auditors in the side balcony were thus disagreeably startled by having sound come from overhead from the rear.

C. CONCLUSION DRAWN FROM THE ACOUSTICAL SURVEY.

The results of the survey show that curved walls are largely responsible for the formation of echoes because they concentrate the reflected sound. It seems desirable, therefore, to emphasize the danger of using such walls unless their action is annulled by absorbing materials or relief work. Large halls with curved walls are almost sure to have acoustical defects.

D. METHODS EMPLOYED TO IMPROVE THE ACOUSTICS.

Reflecting Boards.—The provisional cure was brought about gradually by trying different devices suggested by the diagnosis. In one set of experiments sounding boards of various shapes and sizes were used. A flat board about five feet square placed at an incline over the position of the speaker produced little effect. A large canvas surface, about 12 by 20 feet, was not much better. A parabolic reflector, (Fig. 16) however, gave a pronounced effect. This reflector was mounted over a pulpit at the end of the stage and served to intercept much of the sound that otherwise would have gone to the dome and produced echoes. The path of the reflected sound was parallel to the axis of the paraboloid of which the reflector was a quarter section. There was no difficulty in tracing out the reflected sound. Auditors in the path of the reflected rays reported an echo, but auditors in other parts of the Auditorium were remarkably free from the usual troubles. The device was not used permanently, since many speakers objected to the raised platform. Moreover, it was not a complete cure, since it was not suited for band concerts and other events, where the entire stage was used. Another reflector similar in shape to the one just described is shown in Figs. 17 and 18.

Sabine's Method.—The time of reverberation was determined by Sabine's method. An organ pipe making approximately 526 vibrations a second was blown for about three seconds and then stopped. An auditor listened to the decreasing sound, and when it died out made a record electrically on a chronograph drum. The time of reverberation was found to be 5.90 seconds, this being the mean of 19 sets of measurements, each of about 20 observations. The reverberation was found also by calculation from Sabine's equation (see Section III), taking the volume of the Auditorium as 11,800 cubic meters and calculating the absorbing power of all the surfaces in the room. This calculation gave 6.4 seconds. The agreement between the two results is as close as could be expected, since neither the intensity of the sound nor the pitch used by the author was the same as those used by Professor Sabine, and both of these factors affect the time of reverberation.

Several years later the time of reverberation was again determined after certain changes had been made. A thick carpet had been placed on the stage, heavy velour curtains 18 by 32 feet in area hung on the wall at the rear of the stage, a large canvas painting 400 square feet in area was installed, and the glass removed from the skylight in the ceiling. The time of reverberation was reduced to 4.8 seconds. With an audience present this value was reduced still more, and when the hall was crowded at commencement time the reverberation was not troublesome.

Method of Eliminating Echoes.—Although the time of reverberation was reduced to be fairly satisfactory, as just explained, the echoes still persisted, and were very annoying. Attempts were made to reduce individual echoes by hanging cotton flannel on the walls at critical points. Thus the shaded areas in Fig. 14 were covered and also the entire rear wall in the balcony. Pronounced echoes still remained, and it was evident that some drastic action was necessary to alleviate this condition. Four large canvases, shown in Fig. 19, were then hung in the dome in positions suggested by the results of the diagnosis. A very decided improvement followed. For the first time the echoes were reduced to a marked degree and speakers on the stage could talk without the usual annoyance. This arrangement eliminated the echoes not only on the stage, but generally all over the house. A number of minor echoes were still left, but the conditions were much improved, especially when a large audience was present to reduce the reverberation.

Proposed Final Cure.—The state of affairs just described is the condition at the time of writing. Two propositions were considered in planning the final cure. One proposition involved a complete remodeling of the interior of the Auditorium. Plans of an interior were drawn in accordance with the results of the experimental work that would probably give satisfactory acoustics. This proposition was not carried out because of the expense and because it was thought desirable to attempt a cure without changing the shape of the room. The latter plan is the one now being followed. It is proposed to replace the present unsightly curtains with materials which will conform to the architectural features of the Auditorium and which will have a pleasing color scheme. At the same time, it will be necessary to hold to the features which have improved the acoustics.

Note.—Since the above report was issued certain alterations suggested by Prof. Watson's experiments have been made. These consist largely in the building of a false ceiling and side walls of suitable material, following approximately the original lines, and eighteen inches distant therefrom. The results were entirely satisfactory, as every sound is now distinctly audible throughout the building, and there are no disturbing echoes.

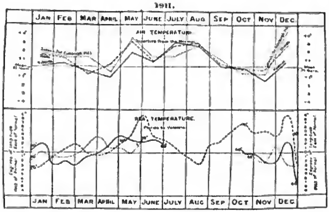
Glazed Frost

Speaking of "glazed frost," by which is meant the smooth coating of ice formed when super-cooled raindrops strike objects, Dr. T. Okada, in the *Journal* of the Meteorological Society of Japan, says: "The conduction and evaporation of raindrops falling through ice-cold layers of the atmosphere will be sufficient to cool them many degrees below the freezing point." The difficulty appears to be to explain why small drops do not solidify in falling through the air.

The Gulf Stream*

Causes That Governs Its Course, and Its Effect on Climate

MANY theories have been advanced to account for ocean currents in general and for the Gulf Stream in particular. Their causation has been attributed by various writers to: (1) Differences in the temperature and density of the sea in widely separated geographical positions. (2) Differences in level due to inequalities in different regions of evaporation and precipitation; and to the overflow of great rivers. (3) To convection currents. (4) To the rotation of the earth on its axis. (5) To the direct action of persistent winds.



Wind is the prime cause of all currents; persistent winds the motive power to which all the great ocean streams may be assigned. If anyone be in doubt as to the fact, let him place tracings of maps on which the direction of the principal current of the globe in the different months or seasons of the year are indicated, over maps on the same scale on which wind distribution, referable to the same months or seasons, is shown, and it will be seen how closely the currents follow the direction of the wind, and how quickly the former respond to changes in the direction of the latter.

In this connection the course of equatorial current of the Indian Ocean, on the western side of the Arabian Sea, may be cited as a striking example. During those months when the north-east monsoon prevails the current in that region turns to the southward and joins the Mozambique current, but as soon as the change in the direction of the wind occurs, and even before the south-west monsoon is established, the current swings round and flows in the new direction of the wind, to the northward and eastward.

All winds by friction cause some movement of the water surfaces over which they blow, while the waves, and even the wavelets they raise, add impulse to the motion; the stronger the wind the greater being its effect at the time. This surface movement caused by wind is gradually imparted to the water layer below it, and when the wind persists in the same direction for long, the motion is transmitted from layer to layer to a considerable depth.

Under the influence of the trade winds, the currents when nearing equatorial regions probably extend to a depth of from 200 to 400 feet.

Although the principal currents are produced and maintained by the action of persistent winds, their direction is largely controlled by the rotation of the earth on its axis and by variation in temperature and in density, also in evaporation and precipitation in different geographical positions; but these exert only slight local modifying effects. Moreover, as regards the Gulf Stream and its causation, it was found by the officers of the United States Coast Survey that the Atlantic Ocean at Sandy Hook was 3 to 4 feet lower than the waters of the Gulf of Mexico at the mouth of the Mississippi. This difference of level, which is said to have been ascertained by accurate measurements, doubtless is caused by the heaping up of water in the gulf by the equatorial current; and the power requisite for maintaining the constant flow of the Gulf Stream through the Strait of Florida must, in a large measure, be attributed to this agency.

The warm, relatively high salinity water which undoubtedly exercises an ameliorating effect upon the climate of our islands and upon that of northwestern Europe generally is mainly of equatorial origin, and is directly attributed to the agency of the Gulf Stream.

In support of this belief, let me refer you, in the first place, to a chart of surface temperature of the North Atlantic in order to show what evidence the distribution of mean annual surface temperature will reveal.

The effect of the collision between the Gulf Stream and the cold Labrador current is boldly marked by the steep temperature gradient from 40 degrees to 46 degrees north. Now trace the course of the isotherms onward. The isotherm of 50 degrees, which on the 50th meridian is in 43 degrees north latitude, on the 28th meridian is in 60 degrees north; the isotherm of 52 degrees, which on the 58th meridian is situated only a few miles south of the 50 degree isotherm, on the 10th meridian is in 57 degrees north; but the isotherm of 60 degrees, which on the 50th meridian is in about 41½ degrees north, reaches the coast of Portugal, after making a curve northward, in about the same latitude. In other words, the surface temperature of the Atlantic between the 43rd and 46th parallels, and the 4th and 32nd meridians is the same as that which is found on the 50th meridian between the 41st and 43rd parallels, where the Gulf Stream and Labrador current meet.

Now let us see what corroborative evidence a chart of average salinity will afford.

In the northern portion of the North Atlantic, the southern portion of the Greenland sea, and the part of the Barents Sea which are enclosed by the 35th and 36th isohalines, are filled with water of the same salinity as that which we find in the Gulf Stream between Cape Hatteras and its place of meeting with the current from the north.

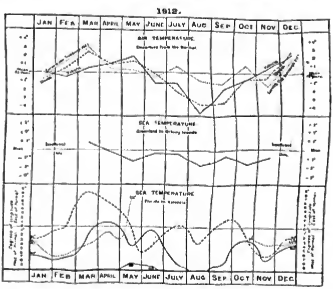
Whether the relatively warm saline stream, or any part of its waters which flows north-eastward from the region south of the Great Bank, is derived from that stream which issues for the most part from the Gulf of Mexico, or, as some aver, is an independent stream which takes its origin in the former locality, is a question which must remain unsettled until the results of further investigations are available. This, at the least, we know, that from the Strait of Florida northward and north-north-eastward to the edge of the Bank; thence north-eastward, as well as eastward, across the ocean, aided, no doubt, by the prevailing westerly and south-westerly winds, there exists throughout the year a continuous flow of warm saline, or relatively warm saline water, to the north-easterly branch of which these islands owe much of their salubrity.

The salubrity of our climate is, of course, largely due to its comparatively mild and even temperature. The relatively small annual range of temperature that obtains normally results from our insular position; the warmth we owe also in a large measure to the surrounding sea, which receives much of its heat from that ocean stream, the course of which we have been following.

I will endeavor to show you by means of diagrams the somewhat frequent correlation of sea temperature with the air temperature over our islands during the decade 1903-1912. In order to confine within manageable limits that portion of the inquiry which relates to sea-surface temperature, the North Atlantic is represented by a broad zone situated between Florida Strait and Valencia in the south-west of Ireland. It happens that the changes in surface temperature, which may be regarded as of premier importance in this connection, occur in this zone.

In the diagrams relating to sea temperature in this Florida-Valencia zone, the excess or defect in the surface temperature is expressed by the number of degrees of longitude in which the 70 degree, 60 degree, and 55 degree isotherms are east or west of their average limit for the month.

Air temperature over our islands is represented, roughly it must be admitted, by the temperature registered at three stations, widely separated: Valencia, Sumburgh Head, in the Shetlands, and North Shields. The curves exhibiting changes in temperature at these places show departures from the normal in degrees Fahrenheit, by reference to the scales above and below a line which represents the average of numerous observations extending over a period of thirty-five years.



The salient features exhibited in the years 1911 and 1912 are as follows:

Sea temperature in the northern half of the ocean is shown to have been slightly in excess of the normal in January; but, as indicated by the 70 degree isotherm, in defect, but increasing, in the southern half. Subsequently it increased to above normal in the south-western Atlantic until the end of February, and declined to the north-eastward during that month. The conditions were reversed in March, a fall in temperature taking place to the south-west, and a rise to the north-eastward. Over the area represented by the 60 degree and 70 degree isotherms temperature rose in April, but declined to the north-eastward. After April sea temperature was in excess of the normal until October, except in the south-west portion of the ocean, when the 70 degree isotherm retreated to the west of its average limit in August. The temperature in this part, however, quickly recovered, the 70 degree isotherm, which was nearly 9 degrees of longitude to the east of its average limit at the end of May, again advanced, and was 7 degrees east of it in October, and 9 degrees in December; but retreating rapidly towards the close of the month. Increased activity of the Labrador current in the two closing months of the year reduced the sea temperature for the most part below the normal in the northern portion of the ocean, although south of the 44th parallel it temporarily rose more than 2 degrees above.

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*From a lecture delivered before the Royal Geographical Society by Commander M. W. Campbell Hepworth, C. B.

As regards air temperature during the year 1911, in the months of January and February, from the close of April to the close of September, and again in December, the temperature of the air over Great Britain and Ireland was in excess of the average; moreover, during the months of May, July, August, and December, it was greatly in excess. In October the temperature was about the same as the average, and in March, April, and November only can it be said to have been in defect.

Throughout the greater part of the year 1912 the curves of air temperature resemble, in a marked degree, those relating to sea surface temperature.

Sea Temperature.—The temperature of the sea surface, which fell below the normal at the close of the previous year, continued in defect during the first three months of the year under notice, except in the south-western portion of the North Atlantic, whereit rose above the normal after the middle of February. The temperature then increased so quickly that in less than a month the 70 degree isotherm was charted 8 degrees to the east of its average limit for March. In the more northern portions of the ocean, the surface temperature, although in defect until after March, rose from the middle of February until April, and in that month the charted results exhibited for the most part, an excess of temperature over the North Atlantic generally. The abnormally warm water, of equatorial origin, that was advancing north-eastward, and had been most noticeable in the south-western Atlantic in March, and between the 40th and 50th parallels of latitude in the following month, reached the north-eastern Atlantic in May, flooding the costal waters off our southern shores, while a decided reduction of surface temperature was taking place in other parts of the ocean.

At the end of May, and in the beginning of June, [illegible] degree isotherm had retreated 6 degrees to the west of its average limits for those months, but a slight temporary recovery of temperature was observed between the 40th and 50th parallels up to the middle of the latter month, when under the cooling influence of the Labrador current the surface temperature rapidly declined, the 60 degree isotherm in August having retreated as much as 13 degrees of longitude to the west of its average limit. In the south-west arm of the ocean the temperature rose during June and July, reaching the average toward the close of the latter month, when it declined, but recovered in September. It again declined during the two months that followed, in the latter of which it became considerable in defect; and, although the sea surface temperature increased in the second half of November, it continued to be below the normal to the end of the year.

To the north-eastward the isotherm of 60 degrees, and subsequently that of 55 degrees, indicated a decided defect in surface temperature to the end of the year; albeit fluctuations are shown which harmonize with the temperature of the surface water to the south-westward, as indicated by the 70 degree isotherm.

For the zone between South Greenland and the Orkneys sufficient data are wanting for the purpose of comparison with normal results, until March, when the surface temperature is shown to have been slightly above the normal. It declined during the following two months, when it stood 1½ degrees below the normal, but it rose to, and remained, ½ degree below the normal in June and July; fell under the influence of the East Greenland Current in August; recovered somewhat in the month following; and exhibited similar fluctuations as those which obtained in August and September during the two remaining months, for which sufficient data are available.

The air temperature over the British Isles during the summer and autumn of 1912, in contrast with that prevailing during the same seasons of the previous year, is found, therefore, to have been below the normal in June to November inclusive, except at the northern station in July and October and at the south-western station in November, at which places it rose slightly above the respective months. It was above the normal in February to May inclusive, except at Valencia, when the excess did not obtain until March; equal to, or nearly equal to, the normal in January, and above in December; at Valencia above in November also.

There appears to be no justification for the assumption that important changes have taken place in the circulation of the North Atlantic during historic times. The velocity and volume of the Gulf Stream exhibit modifications that are non-periodic as well as seasonal—modifications that may occur during any month in any year. When the Stream is abnormally active, its resistance to the Labrador current is probably carried farther north than usual, with the result that its north-easterly branch pursues its course in higher latitudes than obtains normally, and its relatively warm saline waters penetrate to the north-westward of their average limits. When, on the other hand, the Gulf Stream is weaker than is usual, according to the season, the converse happens; the north-easterly branch of the Stream commences its new course after its collision with the arctic current, in lower parallels than those in which it commonly starts, and, possibly, the easterly branch is augmented at the expense of the former; so that the influence of the Stream may be restricted in two ways.

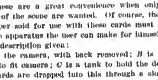
In connection with an investigation undertaken at the Meterological Office, having for its object a comparison of the changes in the strength of the trade winds of the Atlantic[1] with average results, and of changes in the surface temperature of the North Atlantic with normal values, there was found to be some evidence to prove that departures from the average strength of the two trade winds during a series of months, and at times during even so short a period as one month, were roughly reflected in deviations from the normal through the agency of the equatorial current and Gulf Stream in the average distribution of surface temperature in the North Atlantic in the corresponding series of months or month, as the case may be, of the succeeding year, notwithstanding the existence of many other causes affecting the temperature of the surface water, which must tend towards masking the appearance of such connection.

Proof may, therefore, be claimed, resting on a chain of evidence, that many of the climatic changes to which our islands are subject owe their origin to modifications in the trade winds of the Atlantic, communicated through the agency of the equatorial current and its giant offspring the Gulf Stream.

A Positive Postcard Camera

A WRITER in the *Camera* tells how to make an apparatus that can be applied to any camera that will enable the so-called "positive postcards" to be made, and these are a great convenience when only a few copies of the scene are wanted. Of course, the special developer sold for use with these cards must be used, but the apparatus the user can make for himself. This is the description given:

A is the camera, with back removed; *B* is the box, made to fit camera; *C* is a tank to hold the developer. The cards are dropped into this through a slot in the bottom of the box *B*. This tank may be of hard rubber, or glass-lined. I made mine by cutting off the top of a square bottle, and making a box of thin wood to fit around the lower portion of the bottle. The tank should have a flange extending around the top, so that it may be held firmly in place by two buttons on the bottom of the box *B*. *D* is a piece of tin a quarter inch wider than the postcards and a half inch shorter. The two sides are bent around for an eighth of an inch, as shown in *D*. This is fastened in the front end of the box *B* so that it will be exactly in the center. The card is placed into this form on top. The focus will have to be adjusted so that the pictures will be sharp. A few trials will be required to get this, after which the distance should be marked on the front bed of the camera.



I then took a focusing cloth a yard square, and fastened the two sides together so as to form a sack with both ends open. One end of this I tacked around *B* as shown by the dotted lines. On the other end I fastened several glove fasteners, so that when I placed my hand inside I could button this up tight around my arm so as to exclude all light. A tripod-socket and a direct-vision view-finder were then put in place, and a box large enough to hold a package of postcards was made with a lightproof lid, and fastened inside of *B*, on one side near the back.

French Bullets Humane

As CONTRASTED with the numerous statements that have been circulated that poisoned bullets have been used by the French troops, it is a pleasure to note a report on the subject by Prof. Walther Straube in the *Munchener Medizinische Wochenschrift*. During the battles around Mulhausen many French cartridges were found in which the bullets had a black band where they fitted into the shell, and this was commonly believed by the German soldiers to be of a poisonous nature. A number of these cartridges were submitted to Prof. Straube for examination, and he reports that this band is a harmless ring of lacquer. He goes on to state that the bullets themselves are composed of copper, zinc and nickel, and that on analysis they were found to contain no arsenic, phosphorus or antimony, and consequently "of very good material." Furthermore, he says that the copper jacket is so very thin that it is incapable of doing any damage if split off from the core, being a mere film, and therefore the bullets could not be "dum-dumed" by nicking or filing the nose. The conclusion reached by this authority is that "as far as the expression may be allowable, the French bullet must be regarded as humane." This was also the verdict of German army surgeons, who have found the wounds made by these bullets comparatively trivial, and far different from those made by the German and English "spitz" bullets.

It may be safely remarked that none of the nations involved have officially used illegitimate bullets of any kind.

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[1] The Trade Winds of the Atlantic Ocean.

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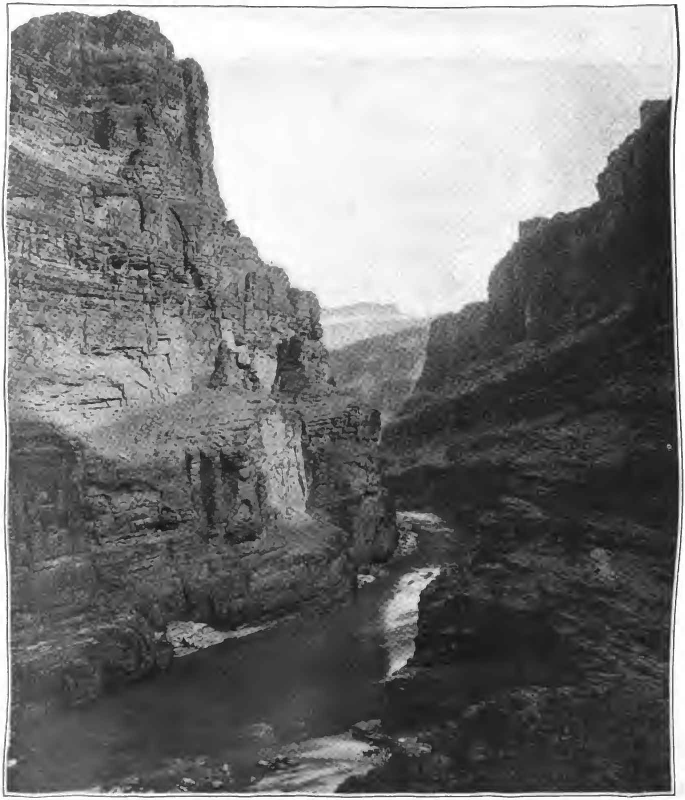

View in Colorado Canyon of a river which has cut a channel much larger than the most extreme requirements of flood flow.
The discharge of the river at this point could be increased a hundred times over that of the greatest flood flow and yet fill only a small part of the canyon which the river has formed.

WHY RIVERS OVERFLOW.—[See page 392.]

Motion Pictures in Colors*

Various Methods by Which the Problem Has Been Attempted

MOTION pictures in colors are produced by coloring ordinary films by hand or by stencil, and also by various modifications of the three-color process of photoengraving.

Coloring by hand is a delicate and laborious operation, because of the large number and small size of the pictures. The work is usually done by women, and it requires close attention, great patience and a skilled eye. It is facilitated and expedited, and its results are improved by division of labor. Each woman applies a single color, the tint and location of which are determined by the chief colorist. The film passes over a number of ground glass tables, such as are used in retouching photographic prints.

The colors, in aqueous solution, are applied with fine brushes, in flat tints and in small quantities, which are absorbed by the gelatine, so that the film dries quickly. Despite all care and skill the color often overflows its assigned limits, but as these errors do not recur regularly in the same places in successive pictures they do not seriously injure the projection on the screen.

When only a few positive films are wanted they are always colored by hand, but when many films are required time and labor are saved by the use of stencils.

The stencils, one for each color, are cut from as many positive films, from each of which the part that corresponds to the given color is removed. For example, the sky of a landscape is cut away from the blue stencil. The cut films are soaked in hot water to remove the gelatine coating and are then ready for use as stencils.

The film to be colored is placed in contact with the stencil, so that their lateral perforations coincide, and the two films are drawn through the coloring machine by wheels having teeth which enter the perforations. In the machine the film and stencil pass either under a flexible roller saturated with the color appropriate to the stencil, or beneath a vaporizer of the air-brush type, which projects the liquid color in a fine spray. In either case the color is applied only to those parts of the film that correspond with the parts cut away from the stencil. The operation is rapid and exact.

The partially colored film is then separated from the stencil and run, with a second stencil, through a second machine which applies a second color, and the operation is repeated until all of the colors desired have been applied.

The difficulty of cutting stencils from the little pictures with the necessary precision has been surmounted by an ingenious artifice. The film to be cut is moved, picture by picture, through a frame placed beside a screen, on which the corresponding pictures of another film from the same negative are projected by a lantern. A tracing point which terminates the long arm of a pantograph is applied to the screen, and a cutting tool which terminates the short arm is applied to the film.

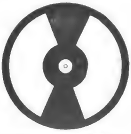

Fig. 3.—Kinemacolor shutter.

The pantograph is so constructed that the displacements of the cutting tool and the tracing point are proportional, respectively, to the dimensions of the film picture and its enlarged projection. The cutting tool is machine-driven and the task of the operator consists merely in tracing on the screen the outline of the parts corresponding to a given color. In this way the stencils are cut with a precision that could not be attained if the little pictures were cut by hand.

THREE COLOR PROCESSES.

Although the colors of nature are infinite in number, they can all be reduced, with respect to the impressions that they produce on the retina, to three fundamental colors: violet, green, and orange-red, by combinations of which all possible tints can be formed. The persistence of retinal impressions makes it possible to effect this combination by successive, as well as by simultaneous, presentation of the fundamental colors. Hence motion pictures in colors can be produced either by simultaneous projection, and exact superposition on the screen, of three films which separately would produce violet, green, and orange-red images, respectively, or by rapid projection of images which present the three colors in regularly recurring series.

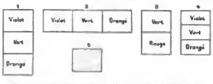

Fig. 1.—Relative lengths of films required by the various processes.

1, Three-color, successive; 2, three-color, simultaneous; 3, kinemacolor; 4, Gaumont chronochrome; 5, autochrome.

In either case the synthesis of the color of any object must be preceded by an analysis, in which a separate photographic negative is made by each of the three fundamental colors. This analysis is effected by photographing the scene through violet, green and orange red screens, or ray filters.

The film exposed behind the violet filter is impressed only by the parts of the scene that contain violet, blue, or red-purple, while yellow is completely stopped by the filter. On development, therefore, this negative film will become opaque in the violet, blue, and purple parts of the scene and will remain more or less transparent in the other parts. The positive printed from this negative will, on the contrary, be opaque in the yellow and transparent in the other parts. If this positive is projected, through a sheet of violet glass, the screen will show a violet picture in which only the violet, blue and purple parts of the scene are represented.

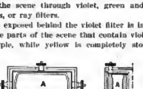

Fig. 2.—Projecting lenses. Gaumont chronochrome.

The green and the orange of the original scene can be reproduced in the same way, by using green and orange filters, respectively, both in making the negatives and in projecting the positives. When the three colored projections are superposed or rapidly alternated the three fundamental colors are unaffected, and the other tints are reproduced by the combination of those colors in varying proportions.

At any point in the picture these proportions are determined by the relative opacities of the three negatives at that point and, consequently, by the proportions of the fundamental colors in the color of the scene at that point.

The white parts of the scene are opaque in all three negatives and transparent in all three positives, so that in the projection the three colored beams of light combine and reproduce white. The black parts are transparent in all three negatives and opaque in all three positives, so that in projection all light is cut off and the part appears black.

The three color process, therefore, is quite simple in theory, but its practical application to cinematography is a difficult problem. In the first place, silver bromide and the human eye do not agree in their sensitiveness to light of different colors. The photographic emulsion is very rapidly impressed by blue and violet, which appear dark to the eye, and even by the invisible ultraviolet, while bright red, orange and yellow produce very little effect upon ordinary films. These differences can be diminished, to some degree, by using orthochromatic emulsion, but even these retain an excess of sensitiveness for the more refrangible rays. Hence the reproduction of the natural colors in their proper relative intensity requires so long an exposure, through the green and orange filters, that instantaneous photography and cinematography are impracticable, except in special cases.

This is not the only difficulty, and none of the processes which have been proposed is free from defects. These processes fall into two groups, in which the analysis and synthesis of the natural colors are effected by successive images or by simultaneous images, respectively.

In the former case all of the partial negatives are made on a single strip of film, successively through violet, green, and orange-red filters. The camera shutter is usually a disk divided into three opaque sectors, which alternate with three transparent sectors, colored violet, green and orange-red, respectively. The mechanism is so constructed that the lens is covered by an opaque sector when the film is shifted, and by a transparent colored sector when the film is halted.

The same device is employed in the projecting apparatus, in which the film and the rotating disk are so adjusted that the pictures that correspond to the violet parts of the scene are projected through the violet sector, and similarly for the other two fundamental colors. The persistence of retinal impressions causes the three monochromatic pictures, if they succeed each other rapidly enough, to combine into one picture in natural colors. It is obvious that, in order to produce perfect fusion and to eliminate flickering, the pictures must be projected three times as rapidly as black-and-white pictures. It follows that the negatives must also be made three times as rapidly as the negatives for black-and-white pictures.

This increase of speed entails serious difficulties. We have seen that the lack of sensitiveness of the emulsion for green and red requires the exposure to be prolonged. If it is necessary, on the contrary, to shorten the exposure the process is restricted to exceedingly luminous objects photographed with a lens of great aperture and correspondingly small depth of field. In the second place, if the speed of the film is tripled, its length and cost are tripled also. (Fig. 1, No. 1.) Furthermore, the film is rapidly worn out by its violent displacement in the projecting apparatus.

The method of combination by simultaneous images does not require any increase in speed, for the three pictures can be placed side by side (Fig. 1, No. 2). The film is no longer than an ordinary film, but it is three times as wide and, consequently, it is as heavy and as costly as the film used in the successive method. The principal difficulty of the simultaneous method, however, is in the exact superposition of the images on the screen.

If the three series of photographs are made with three lenses, placed side by side, and each provided with a ray filter, the positives must be projected by three lenses, similarly placed and provided with ray filters. But, as the distance between the screen and the projecting lantern is variable, the focusing of the three images is complicated by the effect of parallax. The three photographs are taken from different points of view and, therefore, like stereoscopic pictures, they are not exactly superposable.

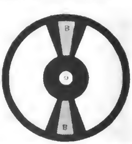

Fig. 4.—Improved kinemacolor shutter.

B, B, semi-transparent blue violet sectors.

If the scene contains only distant objects the three images can be superposed well enough by adjusting the distances between the projecting lenses. Pictures of near objects, the centers of which are accurately superposed, show at the edges colored fringes due to a lack of coincidence in the contours.

Inventors have tried to eliminate this defect by employing, either for making the pictures or for projection, a single lens, behind which the luminous beam is divided into three parts, two of which are deflected by mirrors and prisms to right and left, to form (or to reproduce) the lateral images, while the third part, not deflected, forms (or reproduces) the middle image. The lateral parts of the divided beam traverse a longer path than that of the middle part, and this difference of path must be compensated in order to bring all of the images into focus. The compensation can be effected by the interposition of lenses or of a number of plane-parallel glasses, but the lenses alter the relative dimensions of the images and the bundles of glass absorb much light and greatly increase the weight of the apparatus.

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* Condensed from Ernest Coustet's article in *La Revue des Sciences Pures et appliquées*, and published in this journal.

A great many three color processes have been patented, but few have given good results. The only one that has been exploited successfully in Europe is:

THE GAUMONT CHRONOCHROME PROCESS.

The Gaumont film is of the usual width and contains the three monochromatic pictures in regular recurrence, but each triplet is projected simultaneously. With pictures of the usual dimensions, 18 by 21 millimeters (¾ inch by 1 inch) it would be necessary to advance the film 54 millimeters, or more than 2 inches at each step. In order to lessen the danger of tearing and also to diminish the cost of the film, Gaumont reduces the height of the picture by one third, without altering the width, so that the dimensions are 12 by 24 millimeters (½ inch by 1 inch: Fig. 1, No. 4).

The pictures are projected by three superposed lenses (*A*, *B*, *C*, Fig. 2), the centers of which are separated by intervals equal to the height of a picture, but the lenses are segments of lenses of much greater diameter than this, so that they transmit abundant light.

The middle lense *B* is fixed; the other lenses *A* and *C* can be turned both vertically and horizontally. This rotation is required in order to superpose the images exactly on the screen. The regulation is a delicate operation and the operator is too far from the screen to observe the effect minutely. Therefore, he is aided by an observer placed near the screen who gives him needed warnings by telephone.

The three pictures are illuminated by a single electric arc. Three arcs would give more brilliant projections, but their fluctuations would injuriously affect the coloring. A very intense arc is employed in conjunction with a metallized screen, which, instead of diffusing the light in all directions, confines it chiefly to a small angular field. This method of projection is suitable only for small halls.

The reproduction of natural colors is perfect. This is strikingly shown in motion pictures of gorgeous tropical butterflies and flowers, mounted on rotating pedestals. The movement gives an impression of relief as complete as that produced by the stereoscope, and the illusion of reality is intensified by the play of color, especially in the wings of butterflies, the colors of which are due to interference and change with the direction of the illumination.

TWO-COLOR PROCESSES. KINEMACOLOR.

In the Urban-Smith kinemacolor process the component colors are reduced to two: red and green. The camera and the projecting lantern are similar to those used in the three color process with successive images, except that the rotating disk has only two transparent sectors, red and green, separated by two opaque sectors (Fig. 3). The film moves at the rate of 32 pictures per second, twice the usual speed, and its length (Fig. 1, No. 3) is twice that of a black-and-white film of the same subject.

The absence of the third fundamental color has been partly compensated by substituting for the opaque sectors of the rotating disk blue-violet sectors which are not sufficiently transparent to reveal the movement of the film that takes place when behind them (Fig. 4). By this device the predominant yellow tone of the screen picture is corrected. The blue color is spread uniformly over the picture, instead of being localized in the blue parts, but our eye is very tolerant and the synthesis of color is purely subjective. In the reproduction of natural colors, however, kinemacolor is far inferior to the Gaumont process.

THE AUTOCHROME PROCESS.

The three films and color screens of the three color process can be replaced by a single film composed of violet, green, and orange elements (Fig. 1, No. 5). If the colored elements are very small and uniformly distributed the film will appear colorless. If such a film is coated with silver bromide emulsion and exposed in a camera, the result will be a photograph in colors, in which a deposit of silver covers all of the little colored elements that do not correspond with the natural hues of the subject.

The production of color photographs of this sort has been the object of many researches. The most successful method yet invented is that of MM. A. and L. Lumière, whose autochrome plate is prepared with grains of starch, colored violet, green, and orange, thoroughly mixed and spread in a thin layer between the sensitive emulsion and its support.

This process furnishes beautiful lantern slides, but its application to motion pictures is attended with difficulties that have not yet been overcome. The colored starch grains, and the yellow glass required for correcting the tone of the picture, absorb so much light that, even with an exceedingly sensitive emulsion, the exposure must be at least 60 times longer than in monochrome photography, so that the production of motion pictures is impossible, except in special cases.

If this and other less formidable obstacles can be surmounted the autochrome process will furnish films lighter, less bulky and possibly cheaper than those of the three color process with successive images. It will not be necessary to reduce the height of the pictures or to employ a special lantern for projection.

Producing Steel Direct from the Ore

Many investigators have worked on methods of producing steel direct from the iron ore without resorting to the present preliminary process of reducing the ore in a blast furnace, and it is obvious that if a commercially practical process of this kind can be perfected a very great saving in time and expense will result, together with a considerable saving in ore. As a result of many experiments, it would appear that the electric furnace would give the best results as, for one thing, the uncertainties resulting from impurities introduced by fuel would be entirely avoided. In a recent issue of the *Journal of the Iron and Steel Institute* the results of experiments made by E. Humbert and A. Hethey are discussed. Experiments were made in a normal Héroult electric furnace of 6 tons' capacity, working with single-phase current. Three series of tests were made, namely: (1) Direct reduction of siliceous Swedish iron ore. (2) Direct reduction of Swedish and a siliceous Swedish iron ore, with 30 per cent of scrap mixed with the charge. (3) Direct reduction of Brazilian iron ore. It was found that good steel could be obtained without the carbon being above 0.4 per cent at any time. The steel forged very well and welded easily. The consumption of electrodes was at the rate of 32 kilogrammes per ton of steel. The wear of the lining was approximately the same as when melting scrap, but there was a good deal of ebullition owing to the liberation of large volumes of oxides of carbon. The outstanding quality of steel by this process is its toughness. The authors claim that the steel is more free from harmful gases, such as nitrogen, by this process; and that the direct method has the advantages of simplicity, ability to use refractory and richer ores, freedom from impurities, cheapness, and efficient control of the quality of the steel.

Circumventing Niagara Falls

A New Welland Canal Necessitated by Increasing Traffic

By Bernard Farrows

It was a spectacular feat to drive a canal across the Isthmus of Panama. The world has looked on in open-mouthed astonishment as skillful engineers and toiling laborers have removed mountains, flooded valleys and dug enormous channels so that the commerce of the nations might flow from ocean to ocean.

In a sense it will be a scarcely less picturesque achievement to circumvent that great natural obstacle to the navigation of the Great Lakes of America, the Falls of Niagara, and by providing a ship canal around it, to enable the largest vessels now afloat in these waters to pass with facility from end to end of the long chain of lakes.

The latter task has been undertaken. Indeed, it is now well under way, and almost a year's progress has been made on the preliminary construction work. Awed doubtless by the superior accomplishments of the engineers at Panama, the men who are engaged in the enterprise at Niagara are saying very little about their undertaking, which is perhaps the reason why no one has heard very much as yet about it.

While the Welland Ship Canal, as the waterway is to be called, is to all intents and purposes an entirely new scheme, it will yet supersede a smaller canal which has been in existence many years. The circumventing of the Falls of Niagara is no novelty. It was attempted quite early in the history of lake navigation. As far back as 1829 two ships sailed through the partially completed channel from Lake Ontario to the upper reaches of the Niagara River, and four years later a thorough connection was established between Lakes Ontario and Erie from Port Dalhousie on the former to Port Colborne on the latter.

Since the thirties of last century, the Welland Canal has been twice rebuilt in order to accommodate the slowly enlarging types of vessels in use on the Great Lakes. The present canal, completed in 1880, was regarded at the time as the last word in canal construction. Its locks, twenty-six in number, and of dimensions 270 by 45 feet, were able to hold the largest ships then plying on the upper lakes, while the 14-foot channel was ample for the needs of the days.

But the amazing progress which has been made of late years in marine architecture has produced a type of lake freighter that far exceeds in length, tonnage, and draft the one-time generous measurements of the Welland Canal. The latter has been rendered entirely useless in the case of a large proportion of the shipping of the lakes, and once again the Niagara cataract's barrier has become an effective impediment. Compared with the traffic through the Soo canals, that through the Welland Canal is at present a mere bagatelle, which means that a very large percentage of the commerce of the upper lakes now terminates above the Falls.

As the bulk of the traffic through the canal at present is grain, and as few of the upper lake boats can pass, the Canadian government has recently built at Port Colborn, the Lake Erie entrance, an elevator of 2,000,000 bushels capacity for trans-shipping this grain into smaller vessels.

These facts established the need for a third enlargement of the Welland Canal and were considered by the government of Canada as of sufficient weight to warrant a reconstruction on a very much larger scale. The old route was examined with a view to sizing up its suitability for enlargement. It was promptly condemned, except for the southern section from Allanburg to Lake Erie. This meant a new location for the northern half of the canal and, after much prospecting, a route lying to the eastward of the old route was decided upon. Plans were promptly prepared for the construction of the canal and about a year ago work was started, at an estimated cost of $50,000,000.

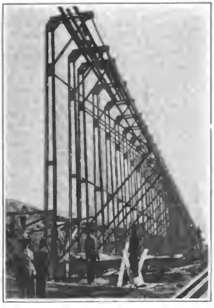
As comparisons often present a more illuminating idea of a subject than plain statements of fact, the importance of the new project may perhaps be better gaged by comparing it with the Panama Canal. The Panama Canal has a length of fifty miles from ocean to ocean; the Welland measures twenty-five miles from lake to lake. The minimum width of the bottom of the channel in the case of the Panama Canal is 300 feet; in that of the Welland Canal it is 200 feet. The minimum depth of water throughout the Panama Canal is 41 feet; in the Welland Canal it is 25 feet, though all permanent structures are to be made so that at any time the channel can be dredged to a depth of 30 feet.

The Panama Canal consists of three sections, viz., the Gatun Lake, formed by the damming of the Chagres River, and the channels leading to it from the Atlantic and Pacific, respectively. The mean level of the lake is 85 feet above sea level and ships are raised to its level by means of six locks, three at either end of the lake. The locks measure 1,000 by 110 feet, with a minimum depth of water over the sills of 41½ feet, when the lake is at its normal level. Each has a lift of 28½ feet.

The Welland Canal, on the other hand, cannot be divided into such well-defined sections. Its course is entirely upward from Lake Ontario to Lake Erie, or, in other words, it has no summit level equivalent to Gatun Lake whence ships must be locked down again. The rise is contained almost entirely within a few miles of Lake Ontario and amounts to 325 feet, the difference in level of the two lakes. This is overcome by means of seven locks, of which Nos. 4, 5, and 6 are double and arranged in flight. The uniform size of the locks is 800 by 80 feet, with 30 feet of water over the miter sills at extreme low stages in the lakes.

There is a further interesting comparison which may be instituted. The larger of the lock gates in the case of the Panama Canal each measure 65 feet in width by 82 feet in height and weigh 730 tons. These gates are of the double-leaf variety, hung on either side of the end of the lock and mitering in the center when closed. In the case of the lock gates for the Welland Canal, a novelty is to be introduced. The latter will not be double-leaf gates, but will be all in one piece and will swing right across the ends of the locks into mortises, They will measure 83 feet in height and 88 feet in width and will weigh 1,100 tons. It is believed by the designer that the new type of gate will be less liable to accident and will prove superior in many respects to the old-style double-leaf gate. The Welland Canal gates will not stand squarely across the channel, but will slant into the opposite wall, the length of the gate being 3 feet more than the width of the canal. The submerged portion of the gate will serve as a floating chamber and will relieve the pivot upon which the gate is swung of much of its weight, although the pin is designed to carry the weight of the gate plus its weight filled with water.

Another point of interest in connection with the Welland Canal locks relates to the source of supply of water for filling them. Hitherto it has been customary to draw the water from the channel above each lock and, when the dimensions were small, this was a satisfactory enough method. But with the huge basins of the new locks to fill each time a ship went through and with the rapid system of operation invented, a strong current would be set up which would interfere with navigation and tend to wear away the banks. Accordingly, above or beside each lock on the new ship canal, provision is being made for large reservoirs of water, from which the supply for filling is to be drawn. The water will consequently enter the locks through the side walls and not through the upper ends, completely obviating the disadvantages referred to.



Steel core framework of retaining wall at the Lake Ontario entrance of the new Welland canal.

The foregoing facts and figures will serve to show that the Welland Ship Canal, while by no means the gigantic project that the Panama Canal was, is still sufficiently near it both in size and in many engineering features to be classed as a notable undertaking. It is true that there are to be found at Niagara a few of the serious obstacles to progress which made the work of building the Panama Canal so long-drawn-out and difficult. Conditions for carrying out the work are much better in the northern hemisphere than in the tropics. The contractors are near their base of supplies; labor is plentiful; the climate is healthy. Above all, there will be no discouraging Culebra Cut to try the patience of the engineers. The going will be comparatively easy and for many miles will consist simply of widening and deepening the existing channel of the old canal. The total excavation, as estimated by the chief engineer, will only amount to 46,000,000 cubic yards, as compared with 230,000,000 cubic yards at Panama.

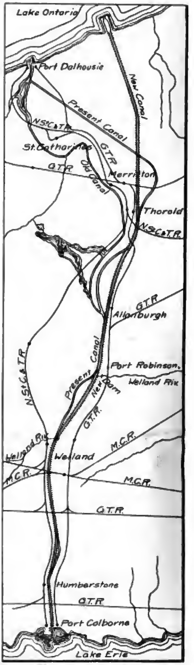
A satisfactory beginning has been made, as already indicated, and from Lake Ontario to the summit of the Niagara escarpment, good progress is to be noted in the work of excavation. The usual methods are in vogue. From the base of the escarpment to the shore of the lake the contractors have built a well-equipped standard-gage double-track railway, along which the material gouged out by the steam shovels is conveyed. For the present it is being used in building the piers that will form the capacious harbor of Port Weller. The lake shore at this point was unbroken and without any natural facilities for forming a harbor. It became necessary therefore to build an artificial shelter for ships entering or leaving the canal, and, accordingly, two piers, 300 feet in width and a mile and half long, are being thrown out into the lake.

From the inner end of the harbor to the entrance of Lock No. 1, which will be located quite near the shore, retaining walls of unique construction are being built. These consist of triangular frameworks of steel, set in solid concrete and reinforced with numberless iron rods. The frames are encased in cement forming a long series of pockets, which in turn are filled in with sand and gravel. It has been demonstrated that this style of wall is quite as effective as solid cement and of much more economical construction.

Naturally, the building of the ship canal is working great changes in the countryside. The section from the lake to the foot of the escarpment crosses what is known as the Garden of Ontario, a district famous for its production of peaches, grapes, and all kinds of small fruits. In its course the canal devastates many fine orchards and has caused the diversion of roads and a general cutting up of the landscape. At least two railways have had to be lifted to new rights of ways to make room for it and one small town has been cut in two by its deep excavations.

As originally estimated, 1918 was to have seen the completion of the work. Owing, however, to conditions imposed by the war which have compelled the Canadian government to cut down their expenditure on the canal, the time of construction will be spread over a longer period, and it may be 1920 or even later before big ships can use the new route from the upper to the lower lakes.

Meantime it is possible to consider the significance of the project and to estimate what its completion will mean to lake navigation. Eight hundred-foot locks and a 25-foot channel mean that not only can lake vessels of the largest tonnage use the canal, but that many ocean liners will be able to pass through to upper lake ports. While much of the traffic of the lakes will continue to terminate at or above Buffalo, there is no doubt that a considerably larger proportion of it than heretofore will descend to Lake Ontario through the new canal. Assuredly, conditions will be very much changed when the Niagara cataract is once more effectively circumvented. The bulk of the freight traffic to be handled on the new waterway will be grain, though there will be enormous quantities of coal and other bulk freight destined for upper lake ports. According to the liberal Canadian regulations, the canal will be free to all vessels using it. It will be of great benefit to the United States as well as to the Dominion of Canada.

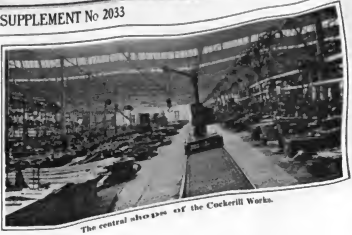


Old and new Welland canals between Lakes Erie and Ontario.

Excavating entrance harbor for the new Welland canal at Port Weller.

Deep cut on the new Welland canal at the top of the Niagara escarpment.

Assembling shops for large work.



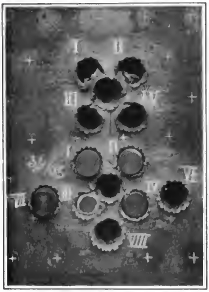
The central shops of the Cockerill Works.

The Cockerill Iron Works

One of the Famous Manufactories of Belgium

By Our Paris Correspondent

The forts of Liège, Antwerp, and Namur which figured so prominently in the recent war events in Belgium had their heavy armor plating constructed at the Cockerill Iron Works, located at Seraing, near Brussels. Cannon and all kinds of heavy war material were also a specialty of this great establishment, and, in fact, the Cockerill plant ranks among the leading iron works in Europe. Since the occupation of Brussels by the Germans, we hear that the works have ceased to run for lack of workmen. The leading position which the great works occupied in the manufacture of war material will make a description of the various parts of the plant a timely one just at present, and the following account is taken from data furnished by the company at a previous period. The Cockerill plant extends over a large area upon the Meuse River and the tracks of the North Railroad lead through it.

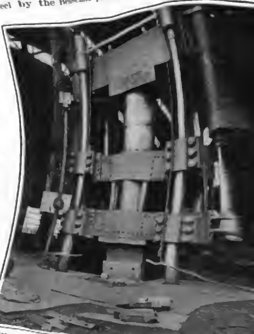


Firing tests on a piece of 8-inch armor plate for cupola forts.

John Cockerill, the son of an English emigrant, became noted at an early age for his mechanical ability, and this contributed in a large part to the progress of the spinning and weaving industry at Liège and Verviers. In 1817 he received from the King of Holland the chateau of Seraing and grounds in order to set up construction works, and the new shops grew rapidly. A few years later the machines built here could rival the best English machines, the only builders of importance at that time. English industries were, in fact, largely introduced on the Continent through the Seraing works throughout the century. A blast furnace operating with coke appeared here in 1824 and worked a revolution in cast iron processes on the Continent; and again, by the use of steam engines for metallurgical work, Cockerill was a pioneer in iron working as well. Considerable credit for steam transport development is due to him and his corps of engineers, and some of the first and most remarkable marine engines were built here in the early stages. It is worthy of note that Ericsson, whose name became so famous, passed the period of 1825-1827 at Seraing, and was engaged in designs of a boat which had high-pressure boilers with inside grate using forced draught, also engines with surface condensation, all of which ideas were, however, too advanced to succeed at that date.

A few years later saw the commencement of railroad building in Belgium, and the enterprise of the Cockerill works was shown by the construction, in 1835, of the first locomotive and the rolling of the first rails to appear on the Continent. From that time on locomotive building made rapid progress at the works, and all the newest European ideas entered into the designs. After that came the industry of drainage pumping engines for mines and the like, and as early as 1847 the celebrated pumping engines of Bleyberg were the most powerful of the Cornwall type used on the Continent. The use of compressed air for power work at great distances, especially for mines and large tunnels, is one of the problems that received its industrial solution at the works, where the engineer Germain Sommeiller in his bold and unprecedented work of tunneling Mount Cenis found the active and ingenious collaborators by whom uld be built the numerous apparatus needed for th vast enterprise.

It was reserved for the Cockerill works to introdu on the Continent what may be termed the leading inve tion in modern metallurgy, namely, the manufacture steel by the Bessemer process, and the first conver



Big forge press for shaping armor plates at the Cockerill Works.

started work in [illegible]. They were also pioneers in practical utilization of blast furnace gases, this being due to their engineers Bailly and F. Kra 1895 there was set up in the shops the first chine of 8 horse-power of Delamarre type, this the first motor to operate on blast furnace gas, industry soon took such a rise that at present th

One of the big shops at the Cockerill Works.

Where special tools, gages, and templates are made.

and their licensees have now built gas engines to the extent of 200,000 horse-power. Passing over the construction of the Diesel engine, which has become a prominent feature, the matter of military construction may be mentioned, in which the works took a leading part. But little of this kind of work was done during the early days of the works, and it was only in 1886 that the Belgian government decided to have all of its war material built in their own country. Since then the Cockerill establishment has taken an important place in the production of military supplies, and it has been so successful as to attract considerable foreign trade. Among the military work which was carried out within recent years was the construction of the cupolas for the forts of Namur and Liège, the armament of the new forts around Antwerp, and the renewal of the field artillery. At a recent date the Belgian government made a long series of trials on fortress material, and as a result it made the choice of the Cockerill steel for the armor plating of cupolas in general. Besides, it adopted the system of cupolas which the company proposed after the designs of engineer E. Ternström. The new system for the defense of Antwerp was entirely based on the application of these interesting constructions.

The area now covered by the works is 375 acres, of which 40 acres are occupied by various buildings. The firm is capitalized at the present time at $2,500,000, and is a stock company. Since the foundation of the works in 1842 to June 30th, 1900, no less than $20,000,000 have been spent for enlarging the works. In this way the raw material resources, coal, ores, etc., were increased and the general development of the works assured. Workmen now employed number about 10,000, and all possible means are taken to secure the comfort and advancement of the men by means of various institutions, such as schools, medical service, and aid given to co-operative enterprises.

One of the largest buildings on the grounds is occupied by the central machine shops, and the great hall measures about 400 feet long by 150 feet wide. One part of the shop is devoted to assembling benches, and the workmen are organized in brigades so as to become skilled in assembling of each type of machine. Two 2-ton electric traveling cranes run in the shop. A special shop contains the tools for work which requires great precision, and here are made the gages and templates which the shops require and all kinds of standard work of this class.

The locomotive works occupy an area of 4,000 square yards and have four electric traveling cranes, capable of lifting loads up to 45 tons, which allows of the ready handling of heavy pieces. Locomotives are taken in and out of the shop on an electric platform of 80-ton load. Here are to be seen types of a light locomotive with vertical boiler for service in shops or on special tracks, and this is one of the firm's specialties. As to large locomotives, most of the types in use on the Belgian state railroads were designed and built here; and among foreign countries furnished France, Italy, Spain, Portugal, and Russia are included. A second shop of 2,000 square yards area is used for light boiler work, sheathing, copper tubes, or mounting of tenders. Locomotives types are in widest variety and go from the lightest up to heaviest kinds used for international traffic.

A special shop of large size is used for assembling of the heaviest types of work, such as large steam engines, blowing machines for blast furnace, pumping machines, rolling mills, or large gas engines. The hall has an area of about 6,000 square yards and contains three divisions, the middle one being about 70 feet high, for assembling of large apparatus, while the side halls have a number of large machine tools. Cranes of powerful build are used here, comprising two electric cranes which can lift 45 tons and run across the main shop at a height of 50 feet. On the same rails is a smaller 5-ton crane. Other travelling cranes of from 5 to 25 tons capacity are installed in the side aisles of the shops, and facilitate the handling of heavy forging and castings, and are convenient for placing such pieces on the machine tools.

The great hall for forging machines was entirely rebuilt in 1880, and has 330 feet length and 65 feet width. One side is occupied by a line of sixteen reheating furnaces. Five electric cranes handle the pieces from furnace to hammer or forge-press, these cranes ranging from 15 to 70-ton type. Large hydraulic forge-presses are to be seen here, such as the 2,000-ton type which is illustrated. Rolling-mill rolls up to 20-ton size can be forged. Production of armor plating is a leading feature of the works. Contrary to the usual practice, the caps for foot cupolas are completely forged in the hydraulic press. Ingots of square section are pressed into plates, and the caps are cut out of these plates in the form of disks; then after reheating, the disks are pressed into convex shape between molds, after which they are carefully tempered and hardened. One illustration represents firing tests made upon a piece of 8-inch armor plate for cupola, and it first took five projectiles fired at a muzzle velocity of 1,500 feet per second. On a second round, it stood eight other projectiles shot at velocities up to 1,700 feet per second.

The artillery works and the various shops therewith connected turn out a great variety of ordnance. Among these we note cannon of fortress and marine types, field guns, rapid-firing cannon, mortars or howitzers of rapid-firing types, special varieties for colonies and others manufactured from nickel steel, also gun carriages and the like. Projectiles are in great variety, and other material of this class.

Other parts of this great plant must be passed over briefly, but mention should be made of the six blast furnaces located on the grounds and the large steel works with five Bessemer converters for 1,000 tons of steel ingots daily, together with three Siemens-Martin furnaces of 15-ton charge which, combined, will give great 45-ton ingots. Much of the coal used comes from mines which are situated on the premises, and ores are brought from Lorraine, Luxembourg, and other places.

Marketing Our Food Products

One of the most important investigations undertaken by the Department of Agriculture, as outlined by the Secretary in his annual report, is in relation to the marketing of food products; and that an improved system is badly needed may be illustrated by the following statement quoted from the report:

"Michigan dressed veal calves expressed to South Water Street commission houses at Chicago have been returned to the identical shipping points from which they came to fill orders from local retail markets."

Similar conditions largely prevail in regard to almost every other product of the farm, and it is evident that some improved system of distribution that will stimulate local markets and eliminate the expense of many intermediate handlings and heavy transportation charges must be developed to counteract the rapidly increasing cost of food, for all of these expenses must be borne by the consumer.

This subject, however, did not originate with the Department, for it is a movement that has sprung up in various parts of the country in response to the realization of the necessity for better methods of marketing; but to be fully effective a system adapted to the whole country should be devised, and this is the work now being undertaken. As a preliminary, information as to what has already been done is being collected, and this will form a most valuable basis upon which to formulate future plans.

"A record of more than 8,500 marketing associations, of about 2,700 co-operative and farmers' elevators, of 2,500 co-operative and farmers' creameries, and more than 1,000 co-operative fruit and produce associations has been secured. While the survey is not complete, it is reported that over a billion dollars' worth of agricultural products are annually marketed by co-operative and farmers' marketing associations.

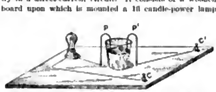
"The conclusion seems justified that in communities where farmers' associations are properly constituted and operated better results are obtained than under a system of individual handling. Advantages present themselves in the standardizing and packing of products and in the discovery of the best daily market. Much information has been secured as to the laws of the various States under which such organizations may be created. The effort is being made to determine the principles on which the enterprises that have succeeded have operated and those upon which the enterprises which have failed have proceeded. Likewise inquiries have been set on foot concerning market centers, the market surplus, the rate of movement, the outlets for commodities, the prices of specific products by definite trade areas, and the possibilities of increasing distribution in an economical way."

Even if these investigations do not lead to any governmental action, the information secured will be invaluable in enabling different sections of the country or individual communities to formulate methods adapted to their requirements.

Detecting Polarity of Electric Circuits

In these days when there is such a multitude of electrical appliances on the market, for every imaginable purpose, it is often desirable to ascertain the polarity of the circuit on which some device is to be used. A sure and simple method of determining this is described by F. P. Ampudia in a recent issue of *Power*.

The sketch shows a simple means of detecting polarity in a direct-current circuit. It consists of a wooden board upon which is mounted a 16 candle-power lamp and socket, in circuit with two terminals C and C' and two pieces of fusible wire P and P' which project into a glass containing water with 8 or 10 drops of sulphuric acid.



Apparatus for detecting polarity in direct-current circuit.

When the terminal posts have been connected to the circuit the lamp will light and bubbles will appear in the glass. Within a short time, one of the leads in the water will become brown and the other a bright gray. The former will denote the positive and the latter the negative wire.

Good Roads and the Government

In his annual report, the Secretary of Agriculture takes a very practical position on the question of good roads and the relation of the Government thereto.

"Good roads are equally intimately related both to the production and distribution of farm products. They are prerequisite not only to economical production and distribution, but also to the promotion of the broader life of the communities. The great need, obviously, is for roads which shall get products from the farm to the nearest railway station, enable the farmer to haul when he cannot sow and reap, and to haul at a lower rate, to transport his children to consolidated schools, and to enjoy comfortably his social enterprises. It is estimated that is costs 23 cents under existing conditions to haul a ton a mile on the average country road, and that this could be reduced by one half if the roads were improved. The problem is partly, of course, one of funds, but even more largely one of methods, of instrumentalities, and of administration. The Nation to-day is spending annually the equivalent of the huge sum of $200,000,000 for roads, an enormous increase in the last decade. Much of this is directed by local supervisors, and it is estimated by experts that of the amount so directed from 30 to 40 per cent is, relatively speaking, wasted or misdirected."

That this should be the case is not in the least surprising when we learn that less than half the States have expert state highway commissioners, and very few of them have any sort of expert local machinery; and this strongly suggests that present methods of distributing the Nation's money on the basis of the political results to be obtained should be revised. In his suggestions for future procedure, the report suggests that if direct Federal aid is to be extended it should be done only under such conditions as will guarantee a dollar's results for every dollar of expenditure, and partly in view of this, it is suggested that "legislation should provide for co-operation between the Federal Government and the States, and that the State, through an expert highway commission, should be the lowest unit with which the Federal machinery should deal. If the law recognizes only a central highway commission, it will strengthen the hands of those that now exist and secure the creation of such bodies in the twenty-six States that do not now have them. The mere creation of such bodies in every State would be a marked gain."

In formulating road schemes, those interested usually find it convenient to omit any reference to the equally important feature of maintenance, but in regard to this the Secretary wisely states that the expenditures of Government money should be limited strictly to construction projects and not used for maintenance, which, he truly says, would involve the Government in a very unsafe and uncertain course.

Training Elephants in the Belgian Congo

The authorities in the Belgian Congo have been making some interesting experiments in raising and training the native African elephants for domestic uses, and results of his work were given by Capt. Laplume, the director of the elephant training station, at the International Congress of Tropical Agriculture. A training station was erected at Api where elephants are particularly numerous. Capt. Laplume captured his first elephants in 1900, and in 1903 he had caught fifteen of these animals. He has now thirty-four. As the young captives became tamer and older, he started training them for agricultural work (carrying, cart-traction, plowing). The station now possesses sixteen elephants perfectly trained to this work. The training of the young elephants is not difficult, and some of the oldest animals are now put to regular work.

The Psychanalytic Movement—I*

Its Services in the Prevention of Insanity

By James J. Putnam, M.D.

I UNDERSTAND that the problem before us for discussion is, How can we best help people to preserve their mental health? and that my part in it is to answer the particular question, What contribution can psychanalysis make toward this end?

It is, however, germane to say that inasmuch as psychanalysis is best definable, from the therapeutic point of view, as an educational method of high value, and since, under all circumstances, it exerts its usefulness largely through helping the patient to become a more thoughtful, more rational, and more mature person, the aims of prevention and the aims of treatment are to a great extent the same.

It is my confident belief that the contribution of the psychanalytic movement to prevention is to become an important one, but that it will make itself felt not so much directly, through the treatment of individual patients, as indirectly and gradually through the stimulus which these searching studies into the nature and history of human motives must exert on parents and educators, in proportion as the principles discovered or emphasized by them become an integral part of psychologic doctrine.

To assert that it is possible to prevent or cure a psychosis by mental influence is equivalent to asserting the psychogenic origin of these diseases. To maintain this is not to deny that special toxic influences, general disorders of metabolism, or abnormalities of cerebral structure or development may play an important part as predisposing causes, or even that the influence which these causes exert in one or another case may have been the controlling influence, *sine qua non*.

It is, however, certain that even where this is so, the mechanism of the psychosis, as a mental phenomenon and as the sign of the occurrence of a mental process having a more or less clearly definable aim and meaning, ought to be specifically studied, and that in order to do this thoroughly the physician should have made himself aware of the patient's inner life, both as an individual and as a member and representative of a social group or social groups.

The psychoses and psychoneuroses are not to be regarded (psychologically) as mere misfortunes or mere accidents, but as phenomena that represent definite, instinctive attempts at readjustment and the securing of some workable equilibrium, on the part of persons whose actual adaptation to their environmental conditions had proved unsatisfactory in the face of this or that special strain, and whose powers of readjustment had shown themselves inadequate to the task of restoring the disturbed balance in any better fashion. This view is in harmony with that of Meyer, Hoch, Bleuler, and others who have stood for a partially psychogenic origin of the psychoses, and have recognized that the constitutional and temperamental make-up of each patient's personality is partially responsible for his illness, or, as I should say, for the method which he instinctively adopts to reassert himself. The psychoses form, in short, one more illustration of the general principle that illness may be classified as the manifestation of efforts toward a certain sort of health.

It seems at first sight almost impossible to get away from the patient's conscious point of view, and to deplore with him and his friends, as if for a misfortune without mitigation, the signs of an oncoming mania or depression or paranoia or dementia praecox. But if, through the aid of knowledge and insight, one can succeed in placing oneself in the depths of the patient's mind, at the center of his vain struggles to make the conditions around him square with his desires, even though these be immature and narrow, it becomes possible to see that his illness may have furnished him a real way out of his perplexity, even if not the one that we, looking on, or he, if possessed of full conscious insight, might have wished to see adopted. The justice of this conception becomes clearer if one scrutinizes, to begin with, the psychologic significance of one's own fits of temporary depression, of the "blues." Whatever else the "blues" accomplish, they certainly afford us the chance to bury ourselves in an ocean of self-engrossment, self-pity, or self-commendation in which we may become for the time being almost as thoroughly immersed as a dementia praecox patient in his delusions. The difference lies in the power of emergence and its special causes.

It occasionally happens that a patient with obsessive fears is intelligent enough (after a certain amount of treatment) and frank enough to see and say that in some respects he feels better satisfied with the prospects offered by his dissociation than by those offered by health; then, namely, when to be well means the facing of situations and renunciations that he is unwilling to contemplate. The only alternative recourse seems to be suicide. As a rule, of course, the logic of the process is concealed from his conscious view. Such persons are somewhat like children, who learn to create, in fancy, a separate realm of feeling and fancy, to which they may retreat[1] for the private enjoyment of emotions in which the other elements of their nature do not permit them openly to indulge. In this realm of fancy the child may become for the time a king, or a being to whom all sorts of excesses of imagination are permissible. If, however, he stays in this realm too long, the return into a life of relative reality[2] and social responsibility may be attended with difficulty. The justification of this comparison only becomes clear when (as sometimes in dementia praecox or paranoia) it is possible to get at the patient's delusions from their deeper and, to him, better side.

What such a child does for a brief space, when he withdraws into this delightful world of fancy, peopled, it may be, by beings from some other sphere,[3] the paraphrenic (i. e., "dissociated" or schizophrenic) patient may—in the terms of this important theory—be said permanently to do. And, *mutatis mutandis*, similar statements may be made for manic-depressive and for paranoid patients. Such persons may, namely, become in different degrees and ways, so preoccupied with the details of their "autistic" life, even when, to the untrained eye, this does not appear to be the case; they may get so immersed in their fantasies and day-dreams that they lose touch, to a greater or less extent, with the life of relative reality.

We are too apt to define each other's tendencies in terms of misfortune, weakness, deficiency, and lack. This procedure is misleading. There is really nothing negative in nature. If a plot of ground does not grow grass, it runs to weeds, but the weeds are as positive in their nature as the grass and often more resistive to destruction.

Life may often be said to consist in the gradual (at times apparently sudden) abandonment of equilibriums which had sufficed well enough up to a certain point, in favor of new and more insistent equilibriums that loom up as representing, as the case may be, a more advanced (sublimated) or a more regressive (infantile) but seemingly more stable stage of evolution or of evolutionary tendency.

It is in the terms of this process that the history of the psychoses should be written.

But I pass, now, from the consideration of the mechanism of the psychoses and the needs of the distinctly neurotic child to the subject of preventive education in the stricter sense, and I attempt again to answer the question, What contribution has psychanalysis to offer.

As I have already indicated, this contribution will perhaps always be mainly an indirect one. I propose nothing so insensate as that parents, or even teachers, should practice psychanalysis; but I maintain that this branch of medicine has something to offer to parents, more to teachers, and a good deal to the family physician. All these classes of persons need to have their own points of view reformed before they attempt to form the character of the child. They need a wider comprehension than that which has been current hitherto, as to what the psychologic nature of the child is, and what his purposes and his dangers are, as expressed in terms of his conflicts, his concealed and repressed thoughts, feelings and desires, and his so often misused imagination; and they need to have this knowledge on the basis of a thorough acquaintance with the psychology of human nature in general, as gained through clinical research.

I presume it will hardly be disputed that the kind of person who most completely fulfils his destiny is he who looks on himself not only as a private and independent individual, but also as at once a member and a representative of the community in which he lives, then of a widening series of communities, and eventually of an ideal and all-comprehensive community. This proposition was long ago made the basis of the educational system of Froebel[4] which should be accepted as offering the best prophylactic method at our command, applicable to all children, though its influence might easily go for nothing unless reinforced by that of the child's environment and home.

But although definitions of this sort are generally accepted as indicating theoretically a suitable scheme of human opportunity and obligation, yet the observation of human conduct leads to the conclusion that the sentiments corresponding to them do not exert the thoroughgoing influence that one might look for. (It [illegible]ously, these sentiments are but imperfectly accepted [illegible] some portion of the minds of most men. The very prevalence of the psychoneurotic illnesses and of the corresponding defects of character and temperament from which all men suffer in some measure indicates that this is true. For many of these forms of illness, as well as many of the defects of character, are largely based on the self-assertion of the individual in the narrower sense, with his demand for personal "rights" and his (largely infantile, and thus selfish) longings and cravings, as against the assertion of his [illegible] his ideal self, recognizant rather of obligations to [illegible] community and of capabilities for usefulness than [illegible] rights.

It may be urged that psychanalysis does not take [illegible] cultivation of social ideals as an end for which [illegible] should directly strive. Technically, this is true. [illegible] psychanalysts know well the evils that attend the assertion of personal desires, cultivated too exclusively in and for themselves, and the importance of the [illegible]site course follows by inference. The primary task [illegible] the psychanalyst is to remove handicaps to pro[illegible] but only in so far as these give rise to painful con[illegible] in the mind. They can, however, see and should [illegible]dorse the schemes of education by which these [illegible]caps are best avoided.

We ought to work for the maintenance of those educational systems and principles that help children to feel and then to see that every man is more [illegible] himself as an independent agent when he feels [illegible] bound to merge his private interests in the interests of persons and causes outside of himself. But this tendency should go, in word and conduct, no farther [illegible] it is expressive of a genuine sentiment.

Social sentiments of this better sort and the [illegible] based on them should not be regarded as [illegible] standards seldom to be reached, but rather as [illegible] to which many persons might measurably attain. [illegible]dren, especially, are natural idealists and respond to appeals which adults often dismiss as idle.

(To be continued.)

Testing High Tension Insulators for Lea[illegible]

AN ingenious method of detecting leaks in the insulators of a high tension electric line has been reported as follows: A specially constructed set of 2,000-ohm [illegible]less telephone receivers is connected on one side to a sharp metal spike driven into the pole carrying the line, and the other side is grounded several feet away by a metal pin in the earth. If the insulators are sound a clear hum is heard of the same tone as in a telephone line; but if one of the insulators is leaking a scratching noise is also heard in the instrument. The particular insulator at fault may then be easily detected by the usual tests between the insulator pins and the cross-arms. This device is saving a great amount of time and labor, as a defective insulator can be detected from the ground, without climbing each pole. It may be said that there is comparatively little trouble from defective insulators now, as great improvement has been made in their quality, and they are all now subject to a test of 120,000 volts for five minutes which quickly eliminates defective work.

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* Abstract of a paper read before the Section on Nervous and Mental Diseases at the Sixty-fifth Annual Session of the American Medical Association, Atlantic City, N. J.

[1] Compare Bleuler's Das Autistische Denken, Jahrb. [illegible] für Psycho-analytische und Pathologische Forschungen, iv, 1.

[2] I say "relative reality," because even the most conventional and usual sort of life gets its form and color from the imagination of each individual. Each person's world is, in part, his personal world alone.

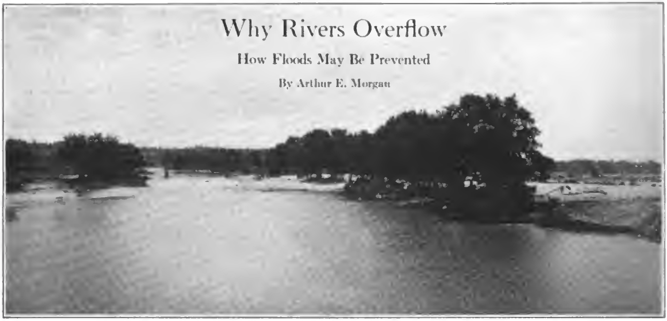
[3] I have a patient at present in mind of good intelligence, but small in stature and timid in temperament, who suffers both from depression and from compensatory ideas of courage. All his life long he has gained great satisfaction from day-dreams of power and prominence. Even at the present time, when he is about 22 years old, he occasionally imagines himself to be a supernatural being, wandering through space in the skies or "talking with God," and dreams of driving a four-horse sleigh or piloting a swift boat into that unknown world from which, in reality, he shrinks.

[4] Froebel: The Education of Man; see also Report on kindergarten by Susan E. Blow and others.

Why Rivers Overflow

How Floods May Be Prevented

By Arthur E. Morgan



Miami River at low stage, about twelve miles below Dayton, Ohio.

Showing erosion of banks by the 1913 flood, and in the distance the piers of a highway bridge which was swept away by the flood. The river here is about 3 feet deep at low water and about 400 feet wide between the natural banks, which are about 7 feet above low water. In the 1913 flood the water rose 22 feet above low water, submerging the natural banks 15 feet and spreading over the valley to a width of one half mile. The channel capacity is about 10 per cent of the flood flow of 1913.

In making engineers and the public acquainted with plans for flood prevention it would seem unnecessary to begin by an explanation of "What is a river?" Yet confusion of ideas and misunderstanding on this point is a most prolific source of difficulty, not only with the public, but with many engineers.

A commonly held impression concerning the origin and functions of rivers might be expressed somewhat as follows:

"As a part of the work of creation it was necessary to design and to create a system of channels for the purpose of carrying to the ocean the surplus water falling upon the land. This being the object for and the manner in which rivers were created, they must necessarily serve the purpose, unless they have been abused in some way. If floods occur and do great damage, it must be because men have cut down the forest or have obstructed the channels, or have occupied a part of the channels which rightfully belong to the rivers."

This attitude was expressed by a U. S. Government engineer who addressed a gathering of people in Ohio after the floods of March, 1913. He is quoted as saying that the flood occurred, not in the rivers as God made them, but in rivers obstructed by *débris*, by buildings in the channel, and by bridge piers.

As a matter of fact, a river is not made to order. It is nothing more or less than the accidental path made by water in following the line of least resistance. There is no necessary relation between channel capacity and flood discharge, and whether the path is large enough to carry flood flows depends entirely upon the natural conditions which have existed while that path was being made. Within the United States one may find rivers in all stages of development, from the river which has entirely lost its channel and is slowly digging a path for itself through the flat coastal plain, to the one which has dug a larger channel than it can ever fill. For instance, the Hudson River from Troy to its mouth, even in times of extreme flood, is no more than the small thread of a stream flowing along the bottom of a deep gorge which the river has cut out for itself during past ages. A still more extreme case is the middle section of the Colorado River, where it flows as a tiny thread at the bottom of a gorge a mile deep. The word "cañon" is used to describe a river channel in which this deepening of the bed has been carried to an extreme.

On the other hand, many rivers fail entirely to dig channels sufficient for the flood flow. The natural and unimproved channel of the Miami River in Ohio has a capacity of about 10 per cent of the greatest discharge, such as occurred last year. The Black River, where it leaves the Ozark Mountains in Missouri, has a drainage area of about 1,450 square miles, and a probable maximum flood discharge of about 140,000 cubic feet per second. The capacity of the river channel through the plains after it leaves the hills is about 4,000 cubic feet per second, or about 3 per cent of the possible maximum flood. The St. Francis River, where it leaves the mountains in Missouri, has a drainage area of about 1,600 square miles, and a maximum flood discharge probably in excess of 150,000 cubic feet per second. It has a channel capacity through the flat lands of a few hundred to about 10,000 cubic feet per second, or from less than 1 per cent to about 5 per cent of the extreme flow. The Coldwater River, in northern Mississippi, has a drainage area of more than 1,000 square miles of hill land in a region of heavy rainfall. Its maximum flood discharge will probably be in excess of 100,000 cubic feet per second, recent flood discharges having been about 40,000 cubic feet per second. Yet the channel of this river, both in the hills and in the flat lands just

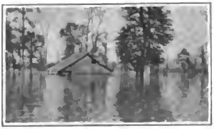


Fig. 6.—During overflow on the Mississippi River.

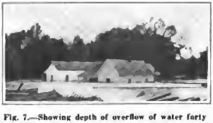


Fig. 7.—Showing depth of overflow of water forty miles back from the river channel—Mississippi River.

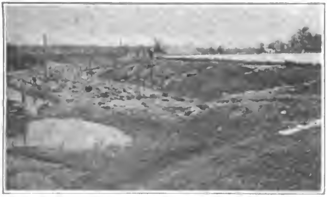


Fig. 9.—Views from land side of a levee during high water.

The sacks of earth are piled along the top of the levee to prevent a break when the levees are overtopped by floods.

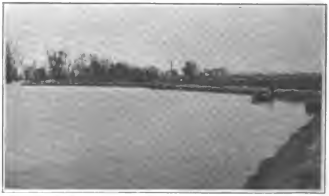


Fig. 10.—View from the river side of levee shown in Fig. 9.

Showing bags of sand piled on the crest of the levee. Later the river rose still further and covered the first row of sacks.

With the breaking of a levee during flood there is a great rush of water as it flows back over the low lands.

If the river were unrestrained by levees it would cover a width of 60 or 70 miles during high water at this point. The levee is on the west bank of the Mississippi River, in Arkansas.

after leaving the hills, has a capacity of about 900 cubic feet per second, or about 1 per cent of the maximum flood flow. The Castor River, in southeast Missouri, has a drainage area of about 300 square miles. In this case, the well-defined channel in the mountains entirely disappears in the flat lands, where the river loses itself in flat, wet woods. The Red River at the east border of Texas, with a drainage area of about 40,000 square miles, will carry at a bank-full stage perhaps 20 per cent of the maximum flood. The upper Nile River along parts of its course not only has insufficient channel capacity, but actually loses its well-defined channel and becomes a broad marsh covering hundreds of square miles. As a matter of fact, it is very seldom that we find a river which has a channel capacity proportioned to its flood discharge. In nearly every case, this capacity is either excessive or deficient, while in some rivers both conditions occur. For instance, the upper Mississippi in many of its reaches has a capacity several times as great as the maximum flow, while through its lower course at a bank-full stage it will carry perhaps not more than half of the maximum. The Colorado River is another example of the same condition.

The fact is, our rivers are not finished creations purposely fitted to fulfill their proper functions. They are accidental affairs, many of them still in the making. Others, especially those flowing through broad, flat valleys which have been built up by the deposit of silt during overflow, come to a state of equilibrium, where the channel is large enough to carry the usual flow. In such cases, the overflow of the flat lands along the rivers, sometimes over great areas, is a normal condition during high water. All such rivers, if they are to serve their purpose, must be controlled, remade, and managed. The following table gives for several rivers the drainage area, the maximum flood flow, the channel capacities, and the channel capacities as percentages of the maximum flood flow.

Name of Stream.	Drainage area, sq. mi.	Maximum flood flow cu. ft. per sec.	Channel capacity bankfull stage.	Channel capacity as percentages of maximum flood flow
Coldwater River, Miss. (where it enters the flat lands from the hills)	1,050	100,000	900	[illegible]
St. Francis River, Mo. (just south of the Ozarks)	1,550	150,000	8,000	[illegible]
St. Francis River, Ark. and Mo. (on boundary between the two States)	1,000	160,000	500 to 5,000	0.3% to [illegible]
Black River, Mo. (at foot of Ozarks)	1,450	140,000	4,000	[illegible]
Castor River, Mo. (at foot of Ozarks)	300	35,000	No channel	......
Red River, Ark. and Tex. (at State line)	40,000	350,000*	60,000	[illegible]
Miami River, Ohio (above Dayton)	1,100	120,000*	12,000	[illegible]
Miami River, Ohio (in Dayton)	2,500	240,000†	80,000	[illegible]
Miami River, Ohio (just below Dayton)	2,540	240,000†	15,000	[illegible]
Miami River, Ohio (below Hamilton)	3,500	300,000†	25,000	[illegible]
Scioto River, Ohio (at Columbus)	1,570	140,000†	30,000	[illegible]

*Flood of 1908. †Flood of March, 1913.

In the case of the Black River in Missouri, of the Coldwater River in Mississippi, and of the Red River in Arkansas and Texas, it has been almost impossible to bring some of the interested people to believe they have on their hands serious problems of river control. So certain are they that it is the divinely appointed function of a river to carry away the [illegible] that many of them believe no improvement is ne[illegible] except the cutting of a bend here or there, the construction of a moderate levee along the banks, the clearing of brush from the channel, or the removal of sand [illegible]

In the Miami Valley, in Ohio, the popular habit of attributing all flood damage to obstructions in channels, especially through the cities, is one of the principal difficulties to be overcome in planning

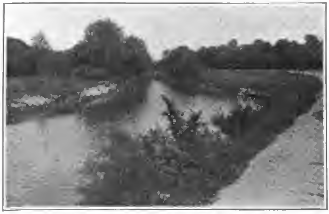


Fig. 5.—Mad River at low-water stage just below Springfield, Ohio, about twenty-one miles above Dayton.

At low water stage the river is here about 5 feet deep. The natural channel is about 200 feet wide between banks which are about 5 feet above low water stage. In the flood of 1913, the banks were submerged to a depth of about 15 feet.

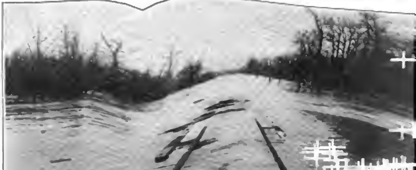
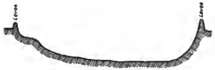


Fig. 8.—During the flood the Mississippi River here is many miles wide, merging with the Yazoo River in Mississippi and with the Arkansas River in Arkansas.

This illustrates conditions described above, where the natural channel of the river can accommodate but a small percentage of the water collected during flood periods, and the overflowing surplus spreads out over many miles of low adjoining country.

protection works. As a matter of fact, in the lower Miami Valley channel capacities within the cities have been maintained and increased until they are to-day much greater than the capacities of the river outside of the cities. Through the main part of the city of Hamilton, Ohio, the capacity of the channel at bank-full stage is about 90,000 cubic feet per second. Above and below Hamilton through agricultural lands where the river channel has been neither improved nor encroached upon it has a capacity at bank-full stage of about 25,000 cubic feet per second. Through the city of Dayton, the river channel has a capacity at bank-full stage of about 60,000 cubic feet per second, and within the levees of about 100,000 cubic feet per second. Through the agricultural lands below the city, where the natural channel capacity has been neither diminished nor increased, the river at bank-full stage will carry 15,000 to 20,000 cubic feet per second. As the discharge during the flood of 1913 was about 250,000 cubic feet per second at Dayton and about 350,000 cubic feet per second at Hamilton, it can be seen that the channels of these streams in their natural unimproved conditions have a capacity of less than 10 per cent of the extreme flood flow, and that through the cities they have capacities of about one third of the extreme flood flow. Under such conditions, determined by actual channel measurements and by stream gagings, it is not correct to assign channel obstructions as the chief cause of flood damage in the cities.

In some cases care has not been taken in determining the cause of flood damage. Take, for instance, a report by U. S. Engineers on conditions at Miamisburg, Ohio, on the Miami River. A little more than a mile below the lower limits of this city the river valley is crossed by a high railroad embankment, which was not overtopped during the flood. The surface slope through this part of the river averaged about 3 feet to the mile. Very careful measurements at the main bridge opening through this embankment show that the water above the embankment at the bridge was 3½ feet higher than below the embankment. The flood level at the lower limit of the city was 4 feet higher, and at the upper limit of the city 11 feet higher than at the upstream side of the bridges, these differences in elevation having been determined by careful measurements. It is evident that this railroad embankment had but little, if any, effect upon river stages in the city where the flood elevation was 4 to 11 feet above the flood elevation at the upstream side of this embankment; yet the following statement appears in the above mentioned report: "It seems clear that the long and massive embankment below the town was the primary cause of the extreme high water, which was said to be from 9 to 11 feet higher than the previous record of 1898. This embankment was built within the past few years and this is the first test by flood." Such a statement, made without ascertaining the facts, leaves behind a residuum of misinformation which must be overcome, especially when the name of the U. S. Government adds prestige to the error. As a matter of fact, the reason why the flood stage in 1913 was 9 to 11 feet higher than that of 1898 is that the discharge in 1913 was about 250,000 second-feet as compared with about 90,000 second-feet in 1898, the entire flow having to pass through a very narrow point in the valley between hills. It should be noted that this bridge and embankment formed one of the most extreme cases of channel contraction to be found in the entire flooded district, and that in few, if any other cases, has any single obstruction caused as great a difference in elevation.



Representative Cross-Section of Miami River in the City of Dayton, O.

Representative Cross-Section of Unimproved Channel of Miami River below Dayton, O.

A careful study of many other situations where flood damage is blamed upon obstructions in the stream channel or in the flood plain will, in general, give the same results; that is, they will show that unless actual measurements and careful examinations are made, the almost universal tendency is to greatly exaggerate the effect of isolated obstructions upon flood stages.

The following quotations from Ohio papers, in opposition to flood prevention works, indicate the extent to which this misconception has been carried:

"It is well known that had our rivers been cleared out and not been encroached upon there would have been no such flood as the one which visited us last March. To neglect in a large measure can much of that terrible inundation be ascribed."—*Troy News*, January 22nd, 1914.

"Dayton's predicament is due to its own greed and lack of foresight. It has builded upon made land which nature formed as a waterway and aside within the past generation or so, encroached upon the river and filled the stream with sub-structure that the waters now have little chance to get through."—*Troy News*, February 27th, 1914.

"Dayton has stolen the channel of the Miami River from the people of the valley and now is trying to hold on to the stolen property and at the same time secure protection from future floods at the expense of the people of all the counties north of Dayton in the great Miami watershed."—*Troy Record*, March 12th, 1914.

These and many similar references are particularly inappropriate in the case of a city which has so improved and protected its river channel as to provide four times the capacity that is provided in the unimproved channel below.

In flood prevention works we should distinguish between rivers having ample channel capacity which never overflow their banks, but which cause flood damage because the actual channel is encroached upon more and more until the flood channel is invaded; and the other type of river which, while having a definite low water channel, flows through a wide flat plain that is overflowed during floods. The lower Hudson, the upper Mississippi and the Potomac are typical of the former, and the lower Red, Arkansas, White, Yazoo, Miami and Tensas rivers, and the Red River of the North, of the latter. In the former cases flood prevention may best be secured by retreating from the flood plain and removing all improvements to higher ground. In the latter cases relief lies in controlling floods so that flood plains are protected.

In very many cases the obstruction of channels has had much to do with flood damage, and the need for effective supervision to prevent further obstruction is becoming more and more urgent. Most European states now exercise strict control of river channels, but European cities are still suffering for the sins of the past. While giving due weight to these considerations, we should not forget that in the case of many rivers the primary cause of floods is that the rivers in their casual development have not dug for themselves large enough channels to carry flood waters.

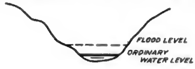


Fig. 1

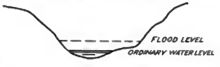


Fig 3

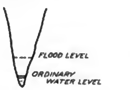


Fig. 2

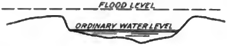


Fig. 4

Fig. 1.—Hudson River, near Mechanicville, N. Y. Ordinary discharge 6,000 cubic feet per second; flood discharge, 110,000 cubic feet per second. Fig. 2.—Grand Canyon of the Colorado, Hardyville, Arizona. Ordinary discharge, 47,880 cubic feet per second; flood discharge, 100,000 cubic feet per second. Fig. 3.—Mississippi River, near Clayton, Iowa. Ordinary discharge, 40,000 cubic feet per second; flood discharge, 450,000 cubic feet per second. Fig. 4.—Mississippi River, near mouth of Red River. Ordinary discharge, 200,000 cubic feet per second; flood discharge, 2,500,000 cubic feet per second. (Approximate bank full capacity, 1,000,000 cubic feet per second.)

Cross-sections of various types of river valleys.

Development of Return-Tubular Boiler Furnace*

By Osborn Monnett †

After using steam jets, the next step in the attempt to keep down smoke in the furnace of a tubular boiler was to build an arch over the combustion chamber back of the bridge-wall, somewhat as shown in Fig. 1. In connection with the steam jets the arch was an improvement, as it broke up the gases and mixed them to a certain extent. However, this design lacked several essential features of a successful furnace, the principal objection being that it did not provide sufficient temperature at the point of mixture. The heat absorption into the boiler was sufficient to reduce the gas temperature to such an extent as to impair combustion of the volatile matter.

An elaboration of this design was the old so-called McGinnis arch setting, which was in quite common use fifteen years ago. This consisted of two arches, one back of the bridge-wall and another over the grates in front of the bridge-wall, as in Fig. 2. This was an improvement over the former setting, because the gases were mixed more thoroughly and the setting gave good service until smoke began to be read more closely. A peculiarity of the setting is that the gases passing under the front arch must make one turn upward over the bridge-wall, another turn along the shell and then come in contact with the back arch, where another change in direction occurs. This will be apparent from an inspection of Fig. 2. Given careful attention, with a judicious use of the steam jets, this setting, while not considered in any sense modern, will give fairly good results. The same objection as to temperature of gases exists and detracts from its efficiency.

Another setting popular in the Middle West from 1885 to 1907 was the Gulickson, shown in Fig. 3. This consisted of a double arch over the bridge-wall with another single-span arch back of the bridge-wall. This construction split up the gases as they passed over the bridge-wall and to some extent mixed them at the second arch. Modifications of the above designs were made without number in an attempt to satisfy the public in the matter of smoke suppression. These attempts embraced various designs of so-called pigeonhole bridge-walls, wing-walls, piers, perforated drop arches, bulkheads, etc., but in nearly every case one or more of the essential features of a successful furnace were missing. All of the above settings were in use up to about 1907,

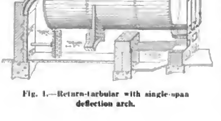


Fig. 1.—Return-tubular with single-span deflection arch.

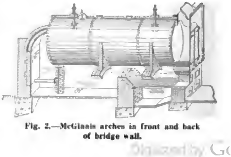


Fig. 2.—McGinnis arches in front and back of bridge wall.

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† Smoke Inspector, city of Chicago.

when the subject was taken up seriously in Chicago by the Department of Smoke Inspection as at present organized.

The best authorities at this time advised surrounding the fire by brickwork and thus maintain a high temperature to increase the ignition and provide a long-flame travel during which combustion could be made complete before the gases came into contact with the heating surface. A number of firebrick-inclosed furnaces of the dutch-oven type were built, some full extension and some half extension, but the majority were flush front, as shown in Fig. 4. At first they were built without and later with a slight drop arch behind the bridge-wall. These settings were not satisfactory, but furnished the information which led to the present ideas on hand-fired furnaces. With these dutch-oven settings the initial expense was high and a great deal of the heating surface in the shell was covered up, with consequent loss of capacity and efficiency, and the setting proved to be difficult to run without dense smoke. It soon developed that mere flame travel in hand-fired furnaces was not sufficient to produce good combustion. It was shown that even where the path of the gases from the grates to the heating surface was excessive, if there were not in this path some form of mixing arrangement that would abruptly change the direction of the gases and bring them into intimate contact, a stratification would take place and smoke would be made. The deflection arches as then built were high and accomplished imperfectly the result sought. They were afterward built lower and lower to get more positive mixture, but still there was smoke.

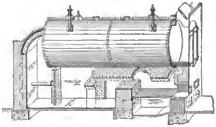

Fig. 4.—Firebrick-inclosed furnace with single-span deflection arch.

The radiating effect from an intensely hot arch over the fire distilled the volatile matter from the fuel more rapidly than it could be mixed with air and consumed in the furnace. In fact, the furnace had a "muffle oven" effect, and puffs of dense smoke were made in spite of the greatest care in operation. Finally, when it became evident that the furnace was not adapted to high-volatile coals, the arches over the fire were removed to reduce the temperature of ignition with a consequent reduction in the rapidity of distillation of the volatile matter. This resulted in a construction similar to that shown in Fig. 5, which is known as the Department No. 4 furnace, consisting of an arch sprung over the bridge-wall and extending back some 3 feet, with a deflection arch to mix the gases. This furnace increased the heat absorption into the boiler by direct radiation from the fire; decreased the rapidity of distillation of the volatile matter by reducing the igniting effect, and resulted in a furnace much easier to run without smoke. A few dutch-oven furnaces equipped with special air admission have survived. They generally burn a picked egg coal, and with careful attention to the air supply have succeeded in running clean.

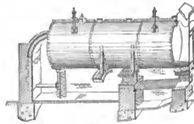

Fig. 3.—The Gulickson setting.

Experiences with the No. 4 furnace, and those that came after it, gradually developed the theory upon which is founded the design of modern hand-fired furnaces as used by the Chicago Smoke Department for high-volatile coals. It became evident that ignition was not necessary to burn this kind of coal; draft was the main essential. As evidence of this, a locomotive with a plain firebox without a brick arch can burn with ease 100 pounds of coal per square foot of grate surface per hour without any ignition except that furnished by the fire itself, because the draft is adequate for the purpose.

In the next place, it was found that a "cool" furnace (one having direct radiation from the fire to the heating surface) not only increased efficiency and capacity by increasing heat absorption, but reduced the liability to dense smoke because the volume of volatile passing off was at no time in excess of the capacity of the furnace to take care of it. All that was necessary then was to provide a zone of high temperature back of the bridge-wall which would maintain the gases at or above the igniting temperature; then provide a deflection arch against which the gases would impinge at this high temperature, and finally, provide air admission over the fire in sufficient quantity to mix in the high-temperature zone with the volatile gases and furnish the necessary oxygen for complete combustion. As from 30 to 35 per cent of the weight of the fuel is in the form of volatile gases, the air necessary to form a proper mixture must be admitted over the fire. With the ordinary draft encountered in stationary practice, it has been repeatedly demonstrated that it is impossible to draw sufficient air through the grates to completely burn the volatile matter. The term "excess air" ordinarily applied

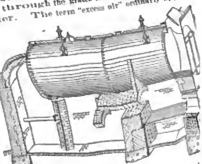

Fig. 5.—Single-arch bridge-wall furnace, wi
span deflection arch (No. 4 furnac

air being admitted over the fire, is not in
excess of the air required to burn the fuel
be remembered that a large proportion of t
the escaping gases, and it must have th
completely consumed.

Dual Aeronautical Motors

To make aeroplanes of value for practical purposes it has been realized that much greater motive power will have to be installed than has heretofore been considered necessary. In this situation the following description of a high power installation, from *The Engineer*, London, will be read with interest:

Herewith we illustrate an arrangement that is being adopted on dirigible balloons and aeroplanes, in which two propellers are used, each driven by a separate engine. Each engine has nine cylinders in the example illustrated, and develops 300 horse-power. As designed for an aeroplane, the arrangement may appear enormously powerful. Nevertheless, 600 horse-power on one machine has already been approached by the Russian designer Sikorsky, while in France a military biplane actually intended to utilize the arrangement herewith illustrated is, we have reason to believe, under construction. It may be noted here that, although these dual engines provide together 600 horse-power, it does not necessarily follow that both engines will normally run simultaneously. They can do so if desired, but means are provided whereby either engine may be employed to drive both propellers, while the other engine is kept idle as a standby in case of breakdown or

The motors shown at AA are each comp
details. Each has its own radiator, pumps
carburetors, etc. The engines are mounted
steel plates, the distance between which is
These frame plates are supported on eigh
buffers designed to enable the engines t
fixed in place and to distribute the dead
working stresses uniformly to the car
Between the motors a change gear box
This box not only reduces the speed, but p
whereby either or both propellers may
either or both engines. The details of
not been divulged to us, but we unders
include two clutches and two couplir
former being operated by a balanced
latter by a hand wheel.

From each side of the box a shaft C
angles to the engine crankshaft. Fle
lings are provided on these shafts at
of the shafts are led into reduction be
supported on special frames F, the
the propeller shafts. These frames
absorb the reaction stresses produ
angled transmission in the boxes
GGGG are in two parts for each m
ated just in front of the propellers,
jected to a good draft.

An oil reservoir H supplying bo
the side of the cab framework, wh
the draft of air. Beneath the
the gasoline reservoir I. A gravity fe
is obtained from the supply tank J
ity of which is 70 liters. Fuel
reservoir to the supply tank h
through vertical gearing from the
silencer N is fitted outside the
both motors.

The propellers, it will be not
They are 4 meters
directions. The shafts C r
900 revolutions
and the motor crankshafts at
speed is therefore first stepp

The weights of the items
approximately as follows: Tw
dredweight, 17¼ hundredweig
dredweight, 4½ hundredweight;
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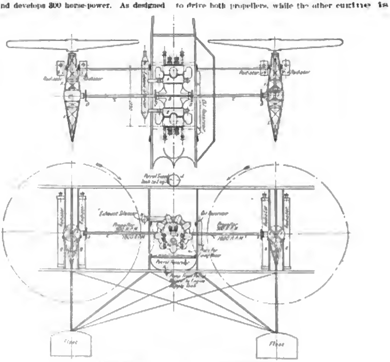

The Salmson dual aero-engine arrangement.

Artificial Daylight—I*

Light Sources Suitable for Color-Matching

By Herbert E. Ives

In the fourteenth century the Glovers' Company of London decreed that "no one shall sell his goods by candle light." When Tyrian purple was the staple cargo of the galleys of Phœnicia, it is safe to say that the buyers of that day early learned by experience to make no purchases by torchlight. Certainly it has long been known among those whose business it is to work with colors that daylight and "yellow candle light" are wide apart, not only in appearance, but also in their effect upon colors. It comes, nevertheless, as a surprise to many to learn how numerous are the industries whose working hours depend upon daylight. Color printing and lithography, dyeing, the painting and viewing of pictures, tobacco sorting, the grading of sugar and flour, the sorting of precious stones, the matching of colored fabrics, the inspection of meats and delicate chemical analysis—these are a few having need for daylight at all hours, to say nothing of the surgeon and the dentist.

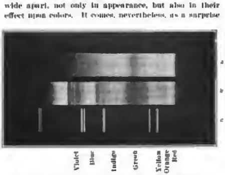

Fig. 1.—Spectra of representative light sources.

a, Continuous spectrum of the Welsbach mantle; b, continuous spectrum with superposed bands, carbon arc; c, line spectrum of the mercury arc.

Among women a knowledge of the defects and pitfalls of artificial light is more general than among men, doubtless because the prevailing fashions call for color in feminine attire. In a big store any day, almost any minute, one may see prospective purchasers of dress goods carrying pieces of goods, or having them carried, to the more or less distant windows to learn their true daylight appearance. For a dress must not look well merely by the artificial light over the counter, but out of doors as well, and frequently is good by one and inharmonious or ugly by the other.

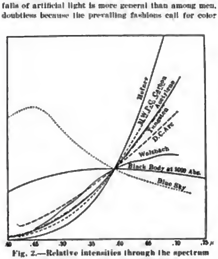

Fig. 2.—Relative intensities through the spectrum of certain representative illuminants.

The fact that, as a rule, artificial light is greatly different in appearance from daylight need be merely noted at this point. Most artificial lights are more or less yellow as compared with the light of the sun or sky. The difference is usually very great, as anyone can convince himself by comparing the two side by side under conditions of approximate equality of brightness for the two. For instance, if two shadows of a pencil are formed side by side by the two kinds of light, such as a tungsten lamp and the sky, the shadow illuminated by artificial light appears orange yellow; that by the sky, deep blue by contrast. Ordinarily we do not appreciate this difference because we do not see the two lights together, and because, if the artificial light is not too strongly colored, the eye by the process of adaptation will in large measure adjust itself to the new distorted color scale—just as a man in walking against the wind unconsciously leans forward. There is a large and interesting problem here for the physiologist and the psychologist to answer: in what way and how much the use of artificial light so different in quality from the light under which the race has been developed may affect the eye and the mind. Certain it is that artificial light is not an unmixed blessing. To its increased use is popularly ascribed many eye troubles. Then, too, many of our habits as social animals seem intimately connected with the use of artificial light. Whether it be the glitter and heat of our ballroom lights, or the color and dimness of our midnight oil, that work their characteristic stimulation, benefits, depression, or ocular injury, or whether these are to be ascribed to their color, is a problem of interest, but here we shall concern ourselves almost entirely with the severely practical question of producing artificial daylight for industrial purposes.

What is daylight? is the inevitable question, for it is at once evident that the setting sun, a clear blue sky, and a "white" cloud are markedly different. So, too, the light reflected into our buildings from snow, grass, foliage, from earth, brick pavements, or gray asphalt is far from being a uniform thing. Daylight is, in fact, quite variable in color, a fact which has led professional color matchers to search for the most constant kind of daylight. This they have decided to be the light from a clear north sky. To the eye this is unmistakably blue in color, hence the problem of producing daylight is not necessarily the same as that of producing "white" light.

In order to answer the question, "What is daylight?" it becomes necessary to measure color. We shall, therefore, first pay some heed to the scientific measurement of color. We shall then apply the methods of color measurement to our present illuminants, natural and artificial, and so learn how they differ from each other.

Various ways of producing artificial daylight will present themselves as a result of this study and will be discussed. Next we shall investigate the problem of why and how colors change in appearance in going from one kind of light to another. From this we shall be led to formulate the necessary characteristics of a color-matching artificial daylight. Some account of the practical achievement of artificial daylight, its various forms, and its characteristics, will follow. Then a little space will be devoted to a study of the distribution of natural daylight out of doors and in rooms, and the possibility of our ultimately copying, at a not prohibitive expense, both the color and the distribution of natural daylight.

COLOR MEASUREMENT.

There are two distinct methods of color measurement. The first is by analysis of the light radiations into their elements and then quantitative measurement of these elements. The second is by analysis according to the effects on the visual apparatus. Properly speaking, the first method is not color measurement at all, since, as will be seen, a color-blind observer or a thermometer, if sensitive enough, may be used to make the measurements. Nevertheless, our problem is an indeterminate one without such measurements, so that they must be treated in detail.

As everyone knows, light may be analyzed or dispersed by means of a prism or grating. Sunlight, when so dispersed, gives the rainbow or solar spectrum with its numerous colors, of which the principal ones are red, orange, yellow, green, indigo, blue, and violet. Any complete study of color must be a study of colored light, since it is only by seeing colored light that we appreciate objects as being colored. The color of an object is, in fact, determined by the completeness with which it reflects or transmits the light which falls upon it. It owes its color to the existence of that color in the light illuminating it. A red glass is red because it transmits the red of the spectrum. For this reason the whole story of an illuminant's behavior as a revealer of color is laid bare when once the light of the illuminant is analyzed completely. These analyses may be considered in two parts—qualitative and quantitative. Qualitatively we note important differences in the spectra of different light sources. Sunlight, for instance, gives a continuous spectrum with no noticeable breaks from red to violet. A candle gives a similar spectrum, but one which will give us some difficulty in seeing the blue and violet portions, unless we arrange our prism device (spectroscope) in a way favorable to bring considerable light to the eye. A carbon arc light shows a continuous spectrum, but one on which are superposed bright violet lines or bands. A nitrogen vacuum tube exhibits several isolated broad bands of colored light. A carbon dioxide vacuum tube shows numerous fine lines and bands nearly filling the entire spectrum. A mercury arc, representing the extreme from the continuous spectrum, exhibits merely isolated bright lines of light. In short, in the incandescent mercury vapor only comparatively few vibrations are represented, which when communicated to the ether produce light waves of those few wave-lengths only (Fig. 1).

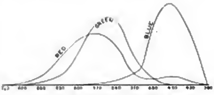

Fig. 3a.—Color sensations in white light.

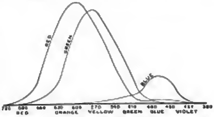

Fig. 3b.—Color sensations in incandescent carbon lamp light.

Considerable information bearing on our special problem is furnished by this merely qualitative survey. It is at once evident that a light totally lacking in any color of the spectrum, such as the mercury arc, which is lacking in red, is not capable of showing that particular color in an object. But this qualitative knowledge must be supplemented by quantitative measurements before it has any real use. Such measurements are usually made by the spectrophotometer, which is, in brief, a spectroscope so arranged that each color may be compared in intensity with the same colored light from a chosen standard light. In place of a standard light it is much preferable to reduce the results to an absolute standard, i. e., to obtain the intensity of the radiation at each wave-length as indicated by the heating effect. The values which are given here have been so reduced as to show these energy values, as though they had been obtained by the use of a bolometer or thermocouple at the observing slit of the spectrometer.

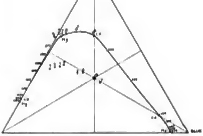

Fig. 4.—Color triangle, showing positions of spectrum colors and representative illuminants.

1, Hefner; 2, carbon; 3, tungsten; 4, Welsbach; 5, D. C. arc; 6, afternoon sun; 7, CO_2 tube; 8, whole light.

Fig. 2 plots in the form of curves the relative inten-

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*Paper read before the Franklin Institute and published in its *Journal*. Copyright, 1914, by the Franklin Institute.

sities throughout the spectrum of certain representative illuminants, including sunlight and blue sky, these latter being the mean of a number of observations by different people. The curves as drawn equal 0.59μ, which is merely a matter of convention, since the actual relative intensities of the lights are not involved. As a matter of fact, this convention practically means that the lights compared are at nearly the same luminosity.

An examination of these curves yields interesting information. Practically all the common artificial illuminants differ from daylight in having an excess of red, orange, and yellow radiations, with a corresponding deficiency in blue and violet. They lie together in an entirely different family from the varieties of daylight. The latter differ in the blue on this scale by less than the factor two, whereas the ratio between day and the artificial lights is from six to twelve. The physical explanation of this lies in the fact that the common illuminants are incandescent solids at comparatively low temperatures, such as 1,500 to 2,500 deg. K., while sunlight approximates in color an incandescent solid or black body at 5,000 deg. K. The practical effects of this characteristic of the common illuminants, such as the incandescent electric lamp, the Welsbach mantle, the gas flame, etc., are two: First, their general yellow color, and, second, their different effects on colored objects. This latter peculiarity will be treated presently.

The second method of color measurement must now be considered. This is derived through color-mixture experiments. It owes its significance to the important fact that colors may look exactly alike which are, nevertheless, composed of quite different radiations, as indicated by the spectroscope. For instance, a mixture of red light and green light produces a yellow which is indistinguishable in hue from a true spectroscopic yellow, i. e., a color showing nothing but a small region of the spectrum around the yellow. Similarly a mixture of yellow light and blue light produces a white indistinguishable from one in which all the spectrum colors are present. Red and bluish green constitute another pair of these "complementaries," as they are called. The most interesting set of mixture colors, however, are red, green, and blue, for it has been found that from these three may be made not only white, but all the colors of the spectrum, and hence all the colors formed by the addition and subtraction of these; that is, all the colors of Nature. It must be clearly understood, however, that these color matches are subjective; that is, they look the same, but of course on analysis with the spectroscope they at once show their composite character.

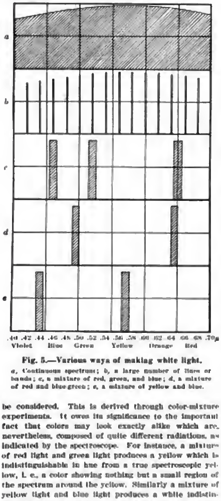
a
b
c
d
e
.40 .42 .44 .46 .48 .50 .52 .54 .56 .58 .60 .62 .64 .66 .68 .70μ
Violet
Blue
Green
Yellow
Orange
Red

Fig. 5.—Various ways of making white light.

a, Continuous spectrum; b, a large number of lines or bands; c, a mixture of red, green, and blue; d, a mixture of red and blue-green; e, a mixture of yellow and blue.

Now this characteristic of red, green, and blue light has led to these colors being called "primaries." They constitute the smallest number of colors out of which all the others may be produced. As such they have had a notable part in making color photography possible. Here we are more interested in the fact that these phenomena of color mixture furnish a method of measuring and representing colors as they appear to the eye, irrespective of their composition.

Taking the spectrum of white light as our standard, it is possible by a series of experiments to determine the quantities of red, green, and blue necessary to match each of the other spectrum colors. Curves may thus be plotted representing these facts, and are called color-mixture curves of the spectrum. This has been done, and it has been found that the true primaries are a certain red, green, and blue a little purer and more saturated than any ordinarily found in the spectrum. These experimentally indicated true primaries are called the primary or fundamental sensations. Fig. 3a shows their distribution in the spectrum, where the units are chosen such that equal quantities of the three sensations give white.

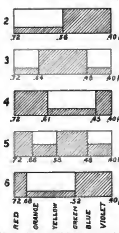

Fig. 6.—Spectral composition of certain arbitrary colors; reflecting power of surfaces or transmissions of absorbing media.

A color may now be specified in terms of but three quantities, instead of a dozen or more, as is necessary with the spectrophotometer. White is equal quantities red, green, and blue sensation; yellow is so much red sensation and so much green, as may be read off the curves. A complex color such as that of an illuminant may be evaluated by multiplying its spectrophotometric value at each wave-length (as compared with white light) by the values of the three sensations at the corresponding wave-lengths and then integrating the curves. Thus the values derived by the use of the spectrophotometer may be translated into sensation values. This transformation process is indicated by the curves of Fig. 3b, in the case of a carbon incandescent lamp.

Still another way to obtain the sensation values is by actually making mixtures of red, green, and blue light to match the color under measurement. If one knows the sensation values of the red, green, and blue lights mixed, the results may be at once translated into terms of the fundamental sensations. Some results of transformations to color sensations from both kinds of measurements of color are shown in the color triangle, Fig. 4.

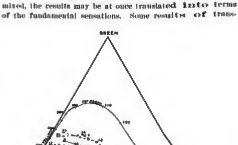

Fig. 7.—Change in color produced by change from daylight (a) to carbon incandescent lamp illumination (b).

The results of measurements in terms of color sensations lend themselves to an elegant and useful diagrammatic representation in what is called the Maxwell color triangle, which we shall have occasion to us later. This triangle is shown in Fig. 4, where the thre fundamental sensations are indicated at the three vertices, white at the center and the various spectrum colors in their appropriate positions around the triangle. A certain property of an equilateral triangle i here utilized; namely, that the sum of the vertical distances of any point from the three sides is equal to th altitude. If, then, the three sensations which constitute a color be represented in such units that their sum is the altitude of the triangle, every color finds a plac in it. White, being equal parts of the three sensations lies at the center.

An interesting and valuable property of the triangl is that mixtures of two colors lie on the line joinin them. Thus the yellow lies on the line joining red an green. White lies on the line joining a large number o pairs of colors, the "complementaries" met with above We can then read off from this triangle what colors are to be mixed to produce any others, among them white

The various sensation values for different illuminants are plotted in the triangle of Fig. 4. This plot again shows how most artificial illuminants differ from white toward yellow, as they are much nearer the yellow of the spectrum than the white center.

METHODS OF MAKING WHITE LIGHT.

As a result of the study of color measurement several methods of artificially making white light present themselves. First and most obvious, theoretically, is the production of an illuminant that has the same distribution of intensity throughout the spectrum as a chosen daylight standard. For instance, if the standard be taken as the color of an incandescent solid at 5,000 deg. Cent. absolute, the direct way to make artificial daylight would be to heat a solid to such a temperature. This of course, we know is impossible with our present facilities for high temperatures and our known refractory substances. Some form of selective radiation, as from certain oxides as yet unstudied, or from gases under electrical discharge, must then be looked to as a possible means of securing directly, without prohibitive temperature, the desired energy distribution in the spectrum.

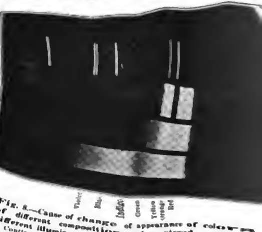

Fig. 8.—Cause of change of appearance of colors of different composition when viewed under different illuminants.

a, Continuous spectrum light source; b and c, two yellow solutions which appear exactly alike when illuminated by light source a; d, line spectrum. Solution c absorbs one of the principal lines of this spectrum and consequently appears different in color from b.

A second method is to subtract, as by a process of absorption, those radiations in an illuminant which are present in excess over daylight. The manner of accomplishing this theoretically is indicated by Fig. 11, where an ordinary artificial illuminant (excess in red, orange and yellow) is to be made to match daylight. Starting with a point on the extreme blue of the spectrum, progressively greater portions of the illuminant's radiations are to be absorbed, as indicated by the area of curve above the cross-hatched portion. Assuming the absorption performed, there remains a spectrum identical in every respect to the standard white light.

A third method of producing white light is indicated by the color-mixture experiments; namely, by the mixing of two or three colors respectively complementary. Fig. 5 shows an illustration of how white light may be made up of (a) a continuous spectrum, (b) a large number of lines or bands, (c) a mixture of red and blue-green, (d) a mixture of yellow and blue, and (e) a mixture of red, green, and blue, the proper quantities of each being taken so that the total of each fundamental sensation is in every case the same.

With these various means at our disposal it becomes necessary to establish criteria upon which the relative merits may be decided. Among such criteria are efficiency and suitability for color matching. The latter requirement is the most important one here, and will next be considered.

THE REQUIREMENTS OF A COLOR MATCHING ILLUMINANT.

What is the relationship between the color of an illuminant and the color of the illuminated object? An answer in one simple case is straightway evident. If the illuminant lacks the spectrum rays which by reflection from a surface constitute the color of the surface, then the illuminant obviously is useless for revealing whether two such non-reflecting surfaces are the same color or not under other and more usual illuminants. But if all the spectrum colors are present, though with varying intensity, it is not so easy to answer the question at issue. We must have recourse to the methods of measurement above outlined.

Let us take a representative color, such as is to be found in a dyed fabric. With a spectrophotometer determine its reflecting power at each wave-length of the spectrum. If we multiply the values obtained by the values of the sensation curves in two illuminants under study, we arrive at the resultant sensations as excited by the light reflected from the fabric under the two different lights. These values may then be tabulated or plotted in a color triangle showing the change in the color of the surface under the different illuminants. On carrying through this operation for the set of arbitrary colors shown in Fig. 6, under daylight and under carbon lamp light, the color triangle data of Fig. 7 were obtained. It is to be seen that, while pure spectrum colors change not at all (since they have no various spectral components to be altered in relative intensity), the colors nearer white are bodily shifted in hue. Purples become reds, greens turn to yellows, and so on. This illustrates the change of color appearance, which is very marked, for the kind of illuminants compared, with purples and lavenders (which become ruddy), blues (which become black), yellows (which appear less strongly colored). But the question of color matching is the paramount one. If two colors match under one illuminant, will they match under another? The answer is evident if we consider the two possible kinds of matches. If we have two yellows, identical as to reflecting power through the spectrum, obviously they will continue to match under any illuminant, since both will be affected alike. But suppose one of them is a mixture of red and green, the other a spectrum yellow. Under white light they are identical in appearance. But when they are placed under a light different in composition, such as a carbon incandescent lamp, the red element of the composite color is unduly accentuated, the green element insufficiently brought out, and the resultant appearance is not the same as that of the simple yellow. This difference may be shown numerically by the use of the color sensation curves and the color triangles. It is illustrated for an extreme case by the spectrograms of Fig. 8. Here are shown (*a*) a continuous spectrum light (Welsbach mantle), (*b*) and (*c*) the spectra of two yellow solutions which match perfectly under this light, and (*d*) a discontinuous spectrum (mercury arc). Note that the absorption band in the second yellow falls exactly over the yellow mercury line; the mercury arc light viewed through this solution is bright green; through the other solution it is yellow. The two solutions look exactly alike by one light, totally different by the other.

It is obvious, from these considerations, that if an artificial daylight is to behave toward all kinds of colors exactly as does real daylight, it must not only look like daylight, but must be identical with it, wave-length by wave-length through the spectrum.

(*To be continued.*)

The Safe Use of Electricity in Coal Mining*

Conditions Under Which Explosions of Gases and Dust May Result from Sparks

By W. M. Thornton, D.Sc., D.Eng.

At present there are 3,500,000 workers in coal mines throughout the world, and there are few mines in which electricity is not used for signaling, lighting or power. On a conservative estimate, the value of the electrical machinery now being installed every year in coal mines approaches $50,000,000, and with the development of the Chinese coalfields this may be expected to increase; but the possible danger from electric ignition of firedamp or coal dust has only been at all fully considered in the last few years. Within five years there have been three great colliery explosions which have had a possible electrical origin. At West Stanley, in Durham, direct electrical ignition of coal dust by a flash from a faulty fuse box was suggested; at Hulton, in Lancashire, ignition of gas at a faulty switch; at Senghenydd, in South Wales, ignition of gas by the spark on a signaling bell circuit. These disasters have directed public attention to the subject with increasing force, and the present notes, compiled at the suggestion of H. M. Electrical Inspector of Mines, give the more important conclusions which have been reached by recent research. It must be said, however, that there is no class of work in which electricity can be used with more advantage than in coal mining; but to insure safety it is necessary to take precautions which are not necessary above ground. For some years competition lowered the quality of electrical mining gear below that on the surface. This is now less usual, and the quality of mining work is in many cases better than surface work, and I am told is especially good in the latest installations in Manchuria. With regard to danger from electric shock, there is nothing peculiar to coal mining, and the risk is not here discussed.

Lower limit of ignition of gas.—The initial ignition in most colliery explosions is of firedamp alone. For this to occur sufficient gas must be present to form a lower limit mixture. If the combustible gas is pure methane (CH_4), the lower limit of inflammability is at 5.6 per cent of gas in air by volume at atmospheric temperature and pressure.[1] If, however, there is ethane or other higher hydrocarbon present, the limit is lowered in inverse ratio to the heat of combustion of the mixture. The calorific value of methane is 189.1 and of ethane 330.6 kilogramme-calories per gramme-molecule. Thus, a mixture in which ethane formed 30 per cent and methane 70 per cent of the combustible gas would have a lower limit of inflammability at 4.5 per cent of gas in air. Such large fractions of ethane are unusual in most large coalfields.

Influence of Temperature.—The most recent work on the influence of temperature on limits of inflammability is that of M. Taffanel, of the French Coal Dust Research Station at Lievin, and M. Le Floch. They have shown[2] that as the temperature is raised the lower limit of inflammability falls. In the case of methane values are given in Table I.

TABLE I.

Initial temp., Cent.	20°	175°	237°	312°	555°	690°
Lower limit.	5.6	5.25	4.75	4.3	3.4	3.0

These are of interest in the case of heat from gob fires, but electric arcs from breaks are transient and local, and we may, in the absence of coal dust, take 5.6 as the lower limit in electrical coal mining practice. It will be shown later that even one half per cent of gas with sufficient dust present helps to forward an explosion.

The Most Inflammable Mixtures.—The usual measure of inflammability of a mixture between the limits has been by the velocity of an explosion wave in it, but the measurements are difficult to make. For the purpose of safeguarding the use of electricity in mines a more convenient test is to find the electric current which, when broken in the mixture, causes ignition by its break spark. The results, using non-inductive circuits—that is, with power factors not less than 0.95 when the current is alternating—are as follows for methane and ethane:[3]

Table II.—*Methane.*

Percentage of gas in air by volume.	Least igniting current.	
	Continuous at 100 volts.	Alternating at 40 ~ 200 volts.
5.6	Lower limit	
6.0	1.4	12.5
7.0	1.20	7.8
8.0	1.0	4.8
9.0	1.07	3.2
10.0	1.20	2.7
12.0	1.30	4.9
13.0	1.65	7.5
14.0	2.00	12.0
14.8	Upper limit	
Most inflammable mixture	8 per cent.	10.2 per cent.

Table III.—*Ethane.*

Percentage of gas in air.	Least igniting current.	
	Continuous at 100 volts.	Alternating at 40 ~ 200 volts.
3.1	Lower limit	
3.5	1.6	12.0
4.5	1.0	7.0
5.0	0.98	6.0
6.0	1.06	4.5
7.0	1.25	4.0
8.0	1.45	4.5
10.0	1.92	10.2
10.7	Upper limit	
Most inflammable mixture	5.0 per cent.	7.0 per cent.

The curves drawn from the continuous and alternating-current values are quite different in type; the former is chisel-pointed, the latter U-shaped and parabolic at the lowest values. In neither case is the most sensitive mixture that for complete combustion. For continuous currents it is below it, for alternating current above it. The least igniting continuous current is very nearly the same for all the paraffin gases.[4] The influence of ethane is, therefore, not to increase the sensitiveness of the mixture to electrical ignition other than by lowering the limit of inflammability. For alternating circuits ethane actually requires greater currents than methane,[5] and the very great increase in the magnitude of alternating as compared with continuous current is the first and strongest argument in favor of the use of alternating current from the point of view of risks from break sparks.

Influence of Inert Gases.—A small excess percentage of nitrogen appears to have a marked effect on the magnitude of the igniting currents. Pit gas containing from 6 to 12 per cent of nitrogen, diluted with air to form mixtures having measured percentage of combustible gas, required the igniting currents to be from one and a half to twice as great as with methane when direct currents was used, and to as much as four times greater when alternating currents, at a frequency of 40, were used for ignition[6]. This point requires fuller examination.

Influence of Circuit Voltage.—The change of igniting currents with voltage is not the same in continuous and alternating circuit. In the former the product of voltage and current is approximately constant over part of the working range; in the latter the current does not always diminish as the voltage is raised, but remains constant over a considerable range of it. An alternating pressure of about 500 is the safest in the sense that, at this pressure, a greater power can be broken without ignition than at any other.

Table IV.—*Igniting Currents for a 9.5 per cent. Mixture of Methane and Air.*

Voltage.	Continuous current at 100 volts.	Alternating at different frequencies.			
		40.	60.	80.	100.
50	2.5	16.0	...	...	...
100	1.6	7.0	16.0	20.0	20.0
200	0.4	3.6	12.2	14.2	19.0
300	0.25	3.5	7.0	12.6	17.0
500	0.2	3.4	8.0	11.0	13.0
700	...	3.0	4.5	10.0	10.7
1,000	...	0.75	1.6	5.5	8.0

Thus, at 1,000 volts alternating current at 40 frequency the igniting current is a little less than at 100 continuous volts.

It can be shown that at a frequency of about 100 a break spark ignites gas with more difficulty than at any other frequency. For all circuits other than large power circuits this frequency is to be recommended from the point of view of safety from ignition by break of cable.

Influence of Self-induction in a Circuit.—Inductance in a circuit, either continuous or alternating, increases the igniting action of a break spark. The energy of the circuit which just causes ignition is the same at all inductances from 0.02 to 0.6 henry[7]—that is, the igniting current is inversely proportional to the square root of the inductance in a circuit. This is most important in signaling circuits in which the inductance of a bell may reach 0.5 henry. The igniting current at this for a single break is 0.5 ampere. Bell circuits in which open sparking may occur, may, therefore, be regarded as dangerous unless otherwise protected.

Signaling by Electric Bells.—The voltage for this purpose in Great Britain is limited to 25, but there are no conditions specified as to its source. It is most usually 6 to 15, except on long haulage roads. The working current taken by an ordinary mining signaling bell may be from 0.15 to 0.4 ampere The inductance of a bell changes with the setting of the vibrating armature, and may be from 0.1 to 0.5 henry. These values are large from an ignition point of view, but the ringing force varies as the square of ampere-turns on the windings (and the break spark, either at the tremble contact or the ringing point on the wires, also as the square of the ampere-turns), so that some such figures cannot be avoided; for if the current is less, the turns, and therefore the inductance, are greater. It is, however, possible by shunting the inductance to remove altogether the risk of ignition. Dr. Wheeler's test on the Senghenydd bells gave the following figures:[8]

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*Paper read before the British Association in Australia.

[1] "The Lower Limit of Inflammation of Mixtures of the Paraffin Hydrocarbons with Air," by R. V. Wheeler and M. J. Burgess. "Trans. Chem. Soc.," 1911, Vol. XCIX., p. 2,013.

[2] "Sur la Combustion des Melanges Gazeux," par. M. M. Taffanel et Le Floch, "Comptes Rendus," Tom. 157, No. 15, October 13th, 1913, 1 595.

[3] "The Ignition of Coal Gas and Methane by Momentary Arcs," by W. M. Thornton, "Trans." Inst. Min. Eng., 1912.

[4] "The Electrical Ignition of Gaseous Mixtures," Roy. Soc. "Proc.," VA., Fig. 2.

[5] *Loc. cit.*, Fig. 12.

[6] "The Comparative Inflammability of Mixtures of Pit Gases Ignited by Momentary Electric Arcs," "Trans." Inst. Min. Eng., Vol. XLVI., part 1, pp. 112-124, 1913.

[7] "The Ignition of Coal-gas and Methane." *Loc. cit.*, Fig. 5.

Mixtures of methane and air were fired by the spark *at the bell trembler* when there was a current of 0.45 ampere passing, and 4.5 volts from secondary batteries having an internal resistance of 0.1 ohm per cell. The bell resistance was 10 ohms, and its mean inductance 0.34 henry. A bell having 0.13 henry inductance required 7.5 volts at 0.7 ampere, with 10 ohms resistance.

No ignition was obtained at the sparks *on the signaling wires* when the voltage was raised to 28 and the current to 1.05 amperes. Shunting the bell coils prevented any ignition up to 24 volts, 1.15 amperes from secondary cells. When wet Leclanché cells are used for ringing, having an internal resistance of 1.5 ohms per cell, the effect is to increase the voltage and current, which can be safely used to beyond the limit of 25 volts allowed by the rules. Since, however, coal gas and air mixtures were ignited with a current of 0.2 ampere passing at 5.5 volts on the bell by sparks on the signaling wires, it would appear that there is not a large margin of safety in ordinary bell circuits. The best bells have very little spark in the bell, but the spark on the wires remains unless the windings are shunted. The actual voltage across the break point, either at the trembler or the wires, is many times greater than the battery voltage, and may approach 200. It has all the qualities of an induction coil discharge, a high voltage with a sharply peaked wave.

Electric Lamps.—Many observations have been made on the ignition of gas by hot filaments, notably by Wullner and Lehmann, Heise and Theim, and Hauser. Recent work at the U. S. A. testing station at Pittsburgh[9] has shown, that for practical purposes, *any modern incandescent lamp* may ignite firedamp if broken in such a manner that the filament is not fractured. The voltage in the lamp is not in itself material, and 2-volt lamps can ignite gas in this way. Small hot-wire lamps are more dangerous than carbon lamps on account of the strength of the filament. On the other hand, the possibility of ignition by fixed and protected lamps, or by portable electric safety lamps, may be regarded as remote compared with that of the open sparks on to the signaling circuits. The spark at the switch in portable safety lamps cannot ignite firedamp; but in a badly constructed lamp there has been ignition of the cell gases. This is, in fact, the most important point to safeguard in portable lamps, the modern forms of which are quite satisfactory.

Ignition by Fuses.—Wullner and Lehmann found that a hot wire appeared to ignite gas at the moment of fusion. This observation is of interest in its bearing on the mechanism of ignition, but for practical purposes it may be said that an open fuse, even for 2-volt circuits, may be regarded as unsafe, though at low voltage ignition is not obtained until a critical current is reached, and the effect depends also upon the ratio of the circuit current to the fusing current of the wire when slowly increased. I have seen bare copper 100-ampere fuses in a haulage house 200 yards from the face in a gassy pit.

Other possible causes of electrical ignition of gas in coal mines are:

Oscillations on Cable Sheaths Due to Surges.—It has been suggested that induced electrostatic oscillations upon the sheath or armoring surrounding a conductor upon which violent oscillations had been momentarily set up by a short-circuit, might have sufficient energy if discharged to an adjoining conductor to ignite gas. I tried this on a length of 200 yards of lead-covered cable, on which a 500-volt short-circuit was made with much power behind it. There were no sparks to be obtained from the sheath, which was insulated from earth, under many conditions of trial, and induction sparks from this cause may be regarded as non-existent or of insufficient energy to be visible in darkness.

Leakage Arcs from Cable Armoring.—When from neglect or breakage the binding of armoring is imperfect, a leakage arc may be set up when a fault develops on the system. The igniting influence of such arcs has several interesting features. It is, in the first place, not much more active in starting ignition than a break spark, the values for continuous-current sparks being as follows:

Table V.—*Iron Poles.*

Continuous voltage.	Least igniting current.	
	Leakage arc.	Break spark
100	0·56 ampere.	1·05
200	0·37 „	0·53
300	0·13 „	0·31
400	0·05 „	0·20
500	0·02 „	0·10

Below a certain voltage the cooling action of the poles rise so rapidly in importance that large currents are required in order to cause ignition. Another point of interest is that the difference between alternating and continuous currents is now greatly diminished, so that for practical purposes the igniting leakage currents may be taken as the same. A third is that the flattening of the current-voltage curves for alternating current previously noticed is now no longer found. Small leakage arcs are very difficult to maintain even between carefully adjusted poles, so that if a leakage arc does persist in mining practice it will probably have a current in excess of any of these quoted values, and any leakage arc current above these values may cause a dangerous arc, though the conditions would have to be exceptionally favorable.

Static Discharge Induced by Steam Jets.—At least one fatality is known to have resulted indirectly from shock caused by static discharge from an insulated telephone wire set up by exhaust steam passing across it. The existence of a brush discharge—a "blue glow"—from leaky steam pipes underground has been observed, and the question raised of its possibly igniting gas. I find that gaseous mixtures cannot be fired by such discharge, or by the more active discharge from needle points at high pressure, *unless a definite spark passes.* This can be easily tried in any electrostatic machine. There may be a large brush glow, but there is no ignition at a bunsen burner until a spark passes. Electrostatic glow does not, therefore, appear to be dangerous in itself in coal mining, though when there is high pressure there is always the possibility of sudden spark discharge on the near approach of another conductor. Even in this case I have observed sparks which did not ignite most sensitive explosive mixtures of methane and air; but electrostatic discharge sparks from large surfaces are particularly dangerous and active in starting ignition.

Static Discharge from Belting.—It is well known that sparks can be obtained from high-speed belting. I have compared the nature and appearance of these with those known to ignite gas, and am of opinion that the discharge of electrification appears to be confined to a small part of the inner surface of the belt, and, though it has a pressure often approaching 50,000 volts, yet the energy of discharge is exceedingly feeble and is not necessarily dangerous. I have not succeeded in lighting a bunsen burner by the sparks from a 6-inch belt. The high velocity and disturbance of air in the neighborhood of the belt is unfavorable to ignition of gas, but it would be well to have any record of sparks from this cause which can be obtained in non-fiery mines.

Static Charge Induced by Movement of Clouds of Dust Across a Conductor.—The electrification produced by the formation of a dust cloud of any fine material has recently been demonstrated by Mr. W. A. D. Rudge,[10] and the suggestion made that on the occasion of a fall of rock and with large clouds of coal and stone dust driven along a road, an insulated conductor, such as a girder or signaling wire, might have become sufficiently charged to spark to a neighboring earthed conductor. Sparks of a centimeter long have been produced in this way under favorable conditions; but, though it has been tried by Mr. Rudge, none have so far been obtained underground by movements of coal or stone dust under practical conditions. As a possible cause of gas ignition this cannot, however, be dismissed, and the continued streaming of dust after a fall which may have released gas is favorable to this as a possible, though not highly probable, cause of explosion.

Sparking by Electrification Produced by Grinding Surfaces under Pressure.—Many substances become electrified when heavily squeezed or sheared. At the time of the San Francisco earthquake the crest of a ridge of rocks in which a fault of several feet was developing were seen at night to be illuminated by a blue electrical discharge. Such a state depends greatly on the scale of the phenomenon, and cannot be reproduced in the laboratory; but during the state of shearing stress before a large fall occurs there may be some such action so that at contact between the falling rocks a spark may be set up. This is a suggestion. Dr. Cadman has actually obtained an ignition of gas by contact between falling stones, but the rocks were soaked (naturally) in bituminous matter. These two causes do not, however, affect the use of electricity in mining.

Sparking by "Wireless" Operations on the Surface.—This must be regarded as an impossible cause, for although sparks can be freely obtained between, say, pieces of arc carbon l
neighborhood of a sea
obtained 100 yards aw
certainly not be produ

Capacity Sparks in
capacity sparks which
capacity of 0.05 mfd.
charged between iron p
age is diminished the cu
ner that the energy is
sparks are obtained from
have been switched off

Electrical Ignition of
Two methods were used
relation.[11] In one the cu
just ignited a cloud of coal
In this case the current w
seven ignitions in 100 tri
filled with weak mixture
gas with air and the same
of ignitions was increased
follows:

Table VI.—*Current 3·5 ampere*

Percentage of methane in air by volume.
0·0
0·25
0·50
0·75
1·0
1·25
1·5

Above one-half per cent th
directly proportional to the p
When the gaseous mixture was
stream through the chamber a
foot a second the number of ig
one half; a still atmosphere is
the initiation of dust explosion.

In the second method the lea
ignite the mixture of gas and dus

The nature of the inflammable
importance, for practically the
tained with pit gas or house gas;
more than a few per cent. It wi
VII that it is again at one half
fluence of the gas begins to be ma

Table VII.

Percentage of gas in air.	Least igniti
	240 volts.
0·0	16·0
0·5	12·0
0·75	7·5
1·0	4·75
1·5	3·4
2·0	2·7

Though the gas at these percentag
tain self-ignition alone it is burnt in ex
helps to bridge the space between t
The dust is, however, the more impo
element for the cross curves from Tab
as abscissa instead of percentage of g
dust-ignition curve and not the gas cur

The new rules under the Coal Mi
prohibit the use of electricity where m
cent of gas is present, a very fair con
regard to initiation of explosions; but it s
that smaller quantities help to transm
where dust is present, and the campaig
dust should aim at prevention rather t
by inert substances.

Electrical Ignition of Coal Dust alone.—
of combustible matter can be ignited by
sparks of flaming induction coil discharge,
work the arc formed are almost alway
The ignition of clouds of coal dust by g
was, therefore, examined in detail,[13] some
are given in Table VIII.

Table VIII.—Least Igniting Currents of Clouds of Du

Volts.	Least current causing ignition.	
	Continuous.	Alternating 40 ~.
100	70	120·0
240	11–18	34·0
275	9·0	32·0
480	3·6–5·8	14·0
635	...	5·2
1,000	...	3·3

Ignition of coal dust is, therefore, more dif
alternating than continuous, and in this it is

---

[8] Report of the Chief Inspector of Mines on the Senghenydd explosion, p. 30.

[9] U. S. A. Department of Mines. Bulletins and Technical Use of Electricity in Mines.

[10] W. A. D. Rudge, "Nature," February 12th, 1914, Roy. Soc. "Proc."

[11] "The Influence of the Presence of Gas upon the
bility of Coal Dust in Air," by W. M. Thornton, B
cation, Birmingham, September 11th, 1913. "T
Guardian," September 19th, 1913.

[12] See the reports of the Home Office Committee on
Explosion.

[13] "The Ignition of Coal Dust by Single Electri
by W. M. Thornton and E. Bowden. "Trans." Ins
Vol. XXXIX., part 2.

gas alone. At the higher voltages the duration of the alternating current are increase, and the risks of ignition become more equal.

Bitumen Cables.—Attention has been recently called[14] to a risk of explosion from the gases given off by bitumen cables at a developing fault on continuous-current circuits. Such faults are greatly increased by electrical endosmose; *with alternating current no such action occurs.* This was shown recently by burying two[15] bitumen cables in wet earth with the copper conductors bared for one half inch. To one of them continuous voltage at 240 was applied for several days, to another the same alternating voltage at a frequency of 40, and records were taken of the leakage currents. That on the continuous cable increased and reached 6 amperes when cut off. The alternating leakage fell rapidly to a minimum of 0.2 ampere. At the end of the trial the continuous-current insulation was found to be broken up and disintegrated for 2 feet each way from the fault; the alternating-current cable showed not the slightest sign of heating or damage. The reason for this is that moisture is carried along by an electric current, and therefore enters a continuous-current negative cable fault, collecting in the ground around it, penetrating to the conductor and lowering its insulation, and sometimes flooding it for many yards. With alternating current the rapid movement of the moisture to and fro under the action of the current dries the fault up by its own friction, and maintains it automatically cured. There is no case on record of gas explosion from an alternating-current cable fault.

Conclusions.—There is no danger from gas alone under about 5½ per cent of gas in air; but, to give a higher margin of safety the use of electricity must be discontinued when there is more than 1½ per cent, a factor of safety of 3.6.

Lighting Circuits.—The least igniting currents found are such that the break of any continuous current might fire gas, but not of alternating current. For instance, in parallel lighting the current for a single 100-watt lamp may ignite gas—with alternating at 40 ~ seven such lamps, and at 100 ~ 29 lamps. All continuous-current series lighting at 500 volts may ignite gas, but alternating never by a single break. Lamps, large or small, must have complete mechanical protection, and lighting cables should be armored.

Signaling Circuits.—Any bell working by make and break may ignite firedamp at the bell under normal conditions, and at the signaling wires under exceptional conditions of inductance in the bell. Coal gas and air mixtures can be ignited under normal conditions by the signal-wires spark. The factor of safety is, therefore, not large. Risk can be removed by modifying the electrical connections in the bell.

Power Circuits.—In 8 per cent mixtures a continuous current power of 1/10 kilowatt in the lower limit; with alternating current 0.54 kilowatt is a 10 per cent mixture at 40 periods. Leakage arcs are only to be regarded as dangerous just before the system breaks down. Armoring is necessary if break sparks are to be avoided, and careful bonding if leakage arcs are not to occur. In general, it is necessary to prevent the possibility of open sparking, though alternating currents may have a large break spark and yet not ignite gas. If the use of electricity is placed under the same controling conditions everywhere as in naked light mines, and always regarded as a possible source of ignition unless the parts are completely protected with metallic armoring and covers, all dangers can be met and guarded against. The risks are even now no greater than those attending the use of flame safety lamps, which in almost every great disaster have been discussed as a possible cause of the original ignition.

The object of the series of researches of which this paper is an abstract is to bring to the consideration of those who are still doubtful that these risks exist, experimental evidence that they are real, and to give the limits at which safety begins.

---

[14] "A case of Gaseous Explosion caused by the Electric Heating of Bitumen in Cable Troughs," by W. M. Thornton and J. A. Smythe. *The Electrician,* August 22, 1913.

[15] Home Office report on Explosions from Bitumen Cables, 1914.

A Four-Thousand-Year Calendar*

It is often desired to know on what day of the week some event occurred, but to ascertain this often requires considerable time and trouble. To meet the situation a calendar has been arranged by Mr. S. F. Kennedy, of Lakeview, Mich., which enables the question to be answered almost immediately for any event, ancient or modern, by a simple reference to the tables given. This calendar covers four thousand years, beginning with the year 1, A.D., so that it will be generally useful for many years to come.

Example 1. The Johnstown flood occurred May 31st, 1889. What day of the week was this? In the table of "Centuries" against 1800 we find the letter *c*. In the first section of the tables find the figure 98, and follow this line across to the column under May, and take the small figure in the column *c*, which is 3. Add this figure to the day of the month, 31 in this case, making 34. In the last column of the tables, at the right, this number is found against Friday, which is the day required.

Example 2. Columbus discovered America October 12th, 1492. Proceed the same as before, but in this case we find two letters, *c* and *d*, against the century, 1400, and as the required date comes in the "Julian" calendar, we take the figure from the column under the second letter, *d*, in the October columns. This is 4, which, added to the day of the month, 12, gives us 16, which is found to be Monday. If the date had been in the "Gregorian" calendar the figure under the first letter would have been taken.

Example 3. Beginning of the Christian era, January 1st, 0. What day was this? In the century table against 0 we find the letters *a*, *b*, and as the event was in the "Julian" calendar we take the figure under the second letter, *b*, for January, which is 5. Adding this to the day of the week gives us 6, which corresponds to Friday.

---

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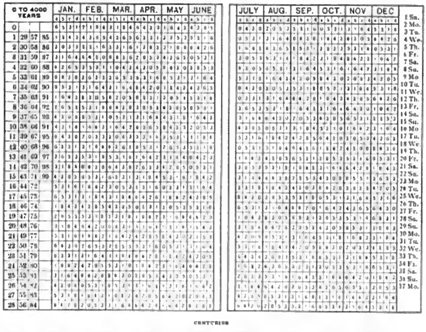
0 TO 4000 YEARS
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEP.
OCT.
NOV
DEC
1 Su.
2 Mo.
3 Tu.
4 We.
5 Th.
6 Fr.
7 Sa.
8 Su.
9 Mo.
10 Tu.
11 We.
12 Th.
13 Fr.
14 Sa.
15 Su.
16 Mo.
17 Tu.
18 We.
19 Th.
20 Fr.
21 Sa.
22 Su.
23 Mo.
24 Tu.
25 We.
26 Th.
27 Fr.
28 Sa.
29 Su.
30 Mo.
31 Tu.
32 We.
33 Th.
34 Fr.
35 Sa.
36 Su.
37 Mo.

CENTURIES

0 a, b	400-a, b	800-a, b	1200-a, b	1600-a, b	2000-a, b	2400-a	2800-a	3200-a	3600-a
100-b, c	500-b, c	900-b, c	1300-b, c	1700-b, c	2100-b	2500-b	2900-b	3300-b	3700-b
200-c, d	600-c, d	1000-c, d	1400-c, d	1800-c	2200-c	2600-c	3000-c	3400-c	3800-c
300-d, a	700-d, a	1100-d, a	1500-d, a	1900-d	2300-d	2700-d	3100-d	3500-d	3900-d, 4000-a

EXPLANATION.—Opposite the given year, under the given month, in Century Column is a little figure which added to the given day of the month at once gives the day of the week in right hand column.

September 2nd, 1752, and all prior dates are reckoned by the "Julian Calendar" and second century letter must be taken. In the present ("Gregorian Calendar") take first century letter.

A Christian University in Cairo.—A fund of $2,000,000 one-tenth of which has already been subscribed, is now being raised in the United States for the purpose of establishing a Christian University, modeled after universities in this country, in Cairo, which is the intellectual center of the Moslem world, and is already the seat of the most famous of Moslem universities.

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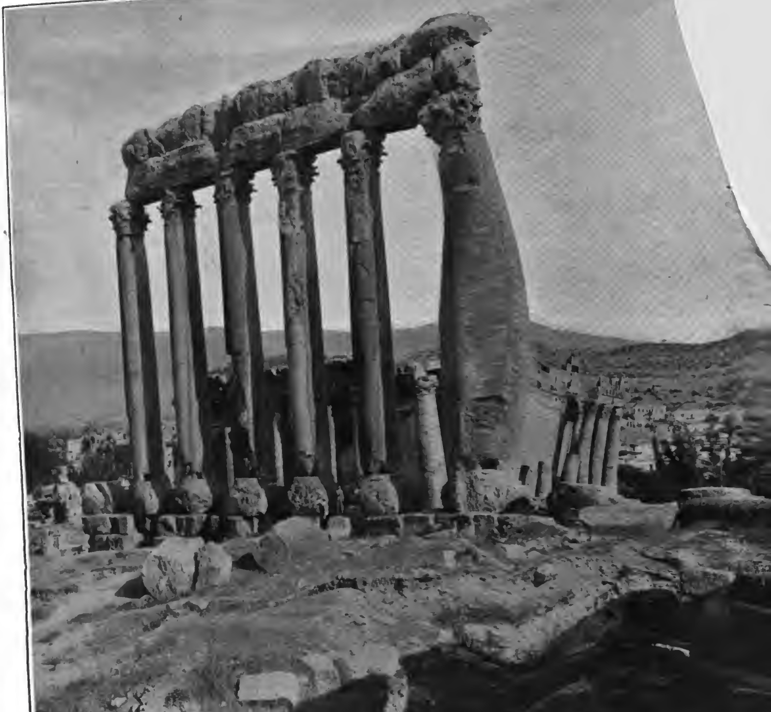

All that remains of a grand peristyle of fifty-four columns.

LOFTY PILLARS OF GREAT TEMPLE, BAALBEK.—[See page 407.]

The Psychanalytic Movement—II[*]

Its Services in the Prevention of Insanity

By James J. Putnam, M.D.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2033, Page 391, December 19, 1914

As illustrative of the kind of service that education can sometimes render, even to very young children, through planting the seeds of the broader sense of social obligations which is so favorable to mental solidarity and health and so hostile to the dissociation that is brought about by repression, I will mention an observation, superficially trivial, but suggestively important.

A small child, who had fallen into habits of theft, became strongly captivated by the idea, which was carefully presented to him, that he could take "with his eyes," instead of with his hands, the things that he longed to appropriate, and thus gain, ideally, the satisfaction of possession, reinforced by the gratification of satisfying a dim social ideal, although obliged to renounce the pleasure of exclusive ownership,[5] with its denial of the social principle. Subsequent developments indicated that this discovery, which appealed, perhaps, primarily, to his imagination only, helped to effect a real change of temperament.

The educational system that has elaborated most thoroughly the methods of inducing or emphasizing this community sentiment as a goal of progress, and has placed them on a practical footing for children between 4 and 6 years old, is undoubtedly the kindergarten system of the great thinker and educator Friedrich Froebel. Kindergartens do not by any means always come up to his ideals, but one cause of this lies in the failure of parents and their advisers to recognize the part which this system aims theoretically to play, and in their failure to give an adequate support to those who are working toward this end.

It is, however, not enough to admit the importance of a general preparatory training of this sort, even if it could be supposed that its principles were to be emphasized through the discipline of the home.

Each child has his own special needs, to be met by appreciative sympathy, direction and correction, and these needs are to be best understood when they are studied in the light of a knowledge of those to whom the tendencies to repression, dissociation, and ambivalence have gone on to a more or less excessive degree.

A certain amount of repression, dissociation, and ambivalence seems to be an inevitable attendant of competitive existence; but it has not been appreciated until recently at what an early stage in the child's life these tendencies may appear. It is true that, with the majority of children, neither repression nor dissociation, nor the tendency to primary or reactive emotional excess that leads to these results, is developed to any very objectionable extent. Children of the best sort, no matter how childlike and, for a time, immature their traits may be, appear to be marked by a characteristic quality that stamps every act as belonging in part to a maturer future of which it may be said to be prophetic, while, perhaps on that very account, it appears also to belong peculiarly to the present moment.

Nevertheless, the pitfalls into which so many children actually stumble (not so much because they are degenerate in the sense of having progressive brain defects, as because their power of adaptation is insufficient for the requirements of life in a given environment) should be recognized as standing open for even the most broadly adaptable child. The earliest years of all children are years of self-engrossment, the finding of themselves in the sensations that attend their reflex acts, their impulses, the recognition of their powers, desires and fears, and as reflected in the attention of their parents. And this period is beset from the outset with the danger that these new-found gratifications and excitements will be taken too exclusively in and for themselves.

The engrossment of these primary, primitive, and elemental pleasures—which soon become modified by the comparisons which children institute between themselves and others, and the instructive discovery of their capacity for compensations and over-compensations—is then more or less superseded by the engrossments of their powers of fantasy, through which the unpleasant realities of the social life, for which they are still unprepared, can be shoved off for a time, in the interest of a more unified life of imagination.

Hand in hand with this tendency comes the recognition of the possibility of repressing what is too distressing, coupled with that of preserving the pleasurable aroma even of excitements that might be reckoned painful.

And here begins the double life of which every child lover should be able to see the traces and the dangers, and also the possibilities of added usefulness.

Children outgrow, it is true, vast numbers of habits which they are tempted to adopt in these earlier years, and it is as objectionable to see signs of permanent mischief in incidental tendencies as it is to overlook their psychologic significance. One may be trustful, but should none the less be watchful.

The principal dangers to which parents are exposed are of a twofold sort. First, they may fail to get any adequate idea of the process which is going on in the child's mind. Next, they may fail to recognize that each child, at each stage of his existence, is instinctively trying to construct a species of unified world, and is using therefor a set of symbolisms which must, perforce, be based on the sensations which he gets from his own efforts and functions, however foreign and trivial, or even revolting, the language of these symbolisms may seem to the adult.

Finally, they may let the desire to seek their own gratification (even though unconsciously) stand in the way of the best interests of the child.

This latter danger is important and familiar, and although not difficult to understand is very difficult to avoid. The love of the parent for the child usually means great devotion; but this is too often given for the sake of a return in kind, and it then partakes of the character of self-love, or mirror love. This sort of devotion fetters the child instead of making him more free, whereas really disinterested love increases the child's independence by arousing in him a corresponding disinterestedness on his part, in a form suitable to his age.

The parent should be a bridge over which the child may pass to a social existence of a wider sort, carrying habits and tendencies of loyalty and service, and feeling within himself a foreshadowing sense of the larger community of which he is to become a part. But, instead, it too often happens that the father or the mother, by dint of the very exclusiveness and intensity of their own affection and the fascination of its exhibition, creates or intensifies a similar exclusiveness in the child's mind, and thus chains him to a set of private gratifications which become sensuous and exacting in proportion as they are asocial. The "father-complex" and "mother-complex" have played with good reason a large part in psychanalytic writing, as in life.[6] Repeatedly have I seen lives that should have been eminently happy threatened with unhappiness through influences like those which I have outlined.

Another important principle which everyone should know is that the fantasies and desires of children, even when their object is something which to the adult seems insignificant or unworthy, have meanings which come near to being good and useful meanings, and may by chance be transformed by good management into something useful and creative.

The intelligent parent will seek to see through the act or the symbol, and to appreciate the child's meanings. These meanings should be divined through real sympathy, based on close but intelligent intimacy, and should be taken at their best value.[7] For it may depend on the turn of this straw whether a desirable outcome finally emerges or whether the act or interest that might have served a good turn as a symbol and then have been replaced, becomes, through repression, the center of a hampering craving. The tendency to relieve, in later years, the fantasy-life of self-indulgent childhood may arise from either of two sorts of causes; an excessive preference for the self-indulgent pleasures first exhibited at an early period when another and better choice might perhaps have been made with almost equal willingness; and a tendency to regression toward those renounced but simpler pleasures, showing itself under conditions of fatigue and strain from which every person seeks instinctively to escape. The child should be protected as far as practicable from both of these dangers, first through having ample inducements offered him for making the best choice, and, next, through being taught to do well and easily the tasks that he is to be called on to do.

In other words, his incitements to the best choice (as, especially, through the imitation of living and historic characters, and through examples afforded by literature), his adaptations and his adaptability should all be held in mind, and with special reference to the specific sorts of dangers that he must encounter.

The imagination of the young child is a weapon of immense power for evil or for good. It can be turned to the support of the reason or to the intensification of sense cravings.

The supplementary addition which I propose to this educational scheme is one that in a certain sense restores the ambivalent principle, as one that when rightly understood is broader than even the principle of independence and power, as commonly conceived. The best man—or child—is not alone a single individual; he is likewise a member of a community, or series of communities, eventually of an ideal community of some sort to which he feels that his loyalty is due and to which he becomes rebound. Similarly, just in proportion to the degree that a man makes himself independent of narrowing ties such as imply slavish dependence, whether based on fear or favor, or longing for approbation and attention, or jealousy or envy, and becomes in that sense independent, he becomes once more dependent on the obligations imposed by his own good qualities and powers, according to the principle hinted at by the term "*noblesse oblige*."

If such a person frees himself from the objectionable and hampering features of his childhood, he should retain, nevertheless, and all the more, the best that his childhood stands for, thus expressing, in his life, all that "religion" literally taken, indicates, namely, a rebinding accompanied by a setting-free. Nothing less than this sort of ambivalence should be, I think, the goal of education for the normal and the neurotically disposed child. This sort of rebinding which should show itself able to meet, at least fairly well, any ordinary test of genuineness is also a goal aimed at theoretically by the educational system of Froebel. It is, of course, not to be supposed that a couple of years even in the best kindergartens, much less in any given school which bears that name, is to be reckoned as a sure prevention against subsequent psychoses, any more than it is to be supposed that every person of the type to which I have above alluded as the best in kind is to be considered as, *ipso facto*, beyond the reach of these dangers. The causative factors ordinarily involved are far too numerous for that, but one reason that I rate so high the possibilities of this system is that, while it aims to use all obvious means for the development of character without needlessly calling the conscious attention of the child to this aim, it recognizes also the importance of taking some measures to prepare the child, through very simple investigations into the results of his own acts, for making labor, even if still only in a simple form, that kind of rational self-scrutiny which psychanalysts have learned to look on as of so much value.

One of the most obvious fruits of this rational self-scrutiny is that—contrary to the usual belief—it is destructive of that morbid, emotional self-scrutiny that goes by the name of introspection and that shows itself so often as a sign and a promoter of the neurotic disposition. I am not wedded to any one plan of education, however, and should welcome any scheme that could show evidences of its capacity to develop character, self-reliance, and the recognition of community obligations.

Let it not be supposed, however, that this claim can, without further inquiry, be made for any and every system that makes a great point, with quasi-military vigor, on the overcoming of difficulties just for their own sake. This has its value, but it is a value that can easily be estimated too highly. After all, it is the personality and previous training of the teacher that are the elements of chief importance. But every such teacher should have been taught to accept a hint from the experience of the psychanalyst, and to use not only general but specific means to make his personality eventually unnecessary to his pupils. The importance of following this rule was pointed out by the able Mme. de Staël, as a consideration worthy the attention of every legislator.

---

[*] Abstract of a paper read before the Section on Nervous and Mental Diseases at the Sixty-fifth Annual Session of the American Medical Association, Atlantic City, N. J.

[5] I am not attempting here a complete explanation of theft-habits, certain roots of which have been shown by psychanalysis to be very deeply rooted in infantile instincts.

[6] Compare papers by Abraham and by Jung in the Jahrb. f. Psychoanal. u. Psychopathol. Forsch., I, 110, 155.

[7] Compare R. L. Stevenson's Lantern Bearers.

"Heads and Tails" and Heredity[*]

Statistical Methods Which May Assist in the Study of New Problems

THE mysteries of heredity have always attracted men of science and men in general. The theory of evolution has explained some of these mysteries, but it has also brought forward new problems, which are still far from solution. The object of this paper is to show the usefulness, in the study of these problems, of certain methods which are called statistical methods and which are based on simple arithmetical deductions from the results of games of chance. In this way we shall learn how it is possible to enunciate, with confidence, laws applying to complex phenomena which we are unable to study in detail.

In many cases we are not interested in the details, and desire only the general result. The wheat grower, for example, cares only for the total quantity and average quality of his crop, not for the individual peculiarities of each grain. This is not quite true of the problems of human heredity, for each child is of supreme importance in the eyes of his parents. Nevertheless, if the average quality of the race can be improved by methods of social hygiene that do not interfere with legitimate individual liberty, the result will have a social value independent of individual advantages. It is worth while, therefore, to apply the statistical method even to those problems of heredity in which the individual point of view possesses the greatest importance.

How can it be easier to solve a complex problem than a simple one? How can ignorance in regard to the simple problem lead to certainty in regard to the complex problem? The answer is given by a study of the commonest and simplest game of chance, "heads and tails."

If a coin is tossed and I wager that it will fall with the head side up, everybody will agree that I have an even chance of winning. If the throw is repeated I again have an even chance of winning, and so on, indefinitely, for the result of any single throw cannot be affected by the preceding throws. As Joseph Bertrand said, the coin has neither conscience nor memory. Yet if we should be told that heads had been thrown fifty times in succession, the result would appear so improbable that we should question the fairness of the play. Here our ignorance of the result of a single throw does not prevent our firm conviction that fifty consecutive throws cannot be won honestly. In order to test the legitimacy of this conclusion, let us consider all of the possibilities presented by a series of throws.

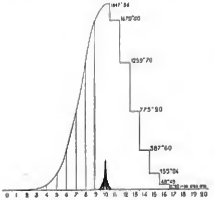

Fig. 3.—Possibilities of twenty throws.

The steps at the right correspond to the piles of Figs. 1 and 2. At the left the steps are replaced by a curve drawn through their middle points. The curve, compared with the Eiffel Tower, shows how large a drawing like Fig. 1 would be.

If there is only one throw, there are only two possible alternatives: head or tail. If there are two throws, each alternative of the first throw may be combined with each alternative of the second throw. Hence there are four possible combinations (head-head, head-tail, tail-head, tail-tail) only one of which contains two heads. If a third throw is added, each of its alternatives may be combined with each of these four couples, producing eight possible triple combinations, only one of which contains three heads. Continuing this process we find that the number of possible combinations is doubled by each additional throw, but that only one combination is composed entirely of heads. The possibilities of three, four and five throws are illustrated in Fig. 1, and those of eight throws in Fig. 2. The corresponding drawing for twenty throws would contain more than twenty million circles, and would fill a sheet of paper more than a mile long if the circles were one centimeter (.04 inch) in diameter. Fig. 3 gives an idea of the size of such drawing, in comparison with the Eiffel Tower. To express the possibilities of 100 throws, supposing that 100 combinations could be indicated on an octavo page, would require 10^{23} volumes of 1,000 pages, which would weigh nearly as much as the earth. Of this vast number of combinations one only would represent the case in which heads are thrown 100 times in succession. This combination is as likely to occur as any other definite combination, for example, that of heads in all odd throws and tails in all even throws. The combination last mentioned, however, is but one of a very large number, each of which gives 50 heads in 100 throws.

These examples show that the laws of chance confirm the statement that exceedingly improbable events never occur. To take another illustration from Joseph Bertrand, it will never happen that a particular paving stone in a city square remains dry after a whole day of rain, although there is no reason why any individual drop should fall on that stone, rather than on the next one.

Let us apply these principles to certain phenomena of heredity, which are called Mendelian, because they were first observed by an Austrian monk, named Mendel. Suppose the individuals of a species of animals or plants are of two kinds, which we may call white and black. The distinction may, or may not be, one of color but, for the sake of brevity, we give the name "white" to individuals possessing a certain character, and the name "black" to individuals possessing the opposite character.

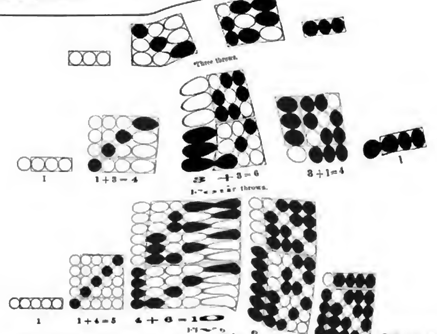

Fig. 1.—Possibilities of three, four, and five throws in "heads and tails."

Each possible combination is represented in a row of circles, white for heads and black for tails. Rows having the same number of white circles are arranged in a pile which comprises as many rows as there are combinations containing that number of heads.

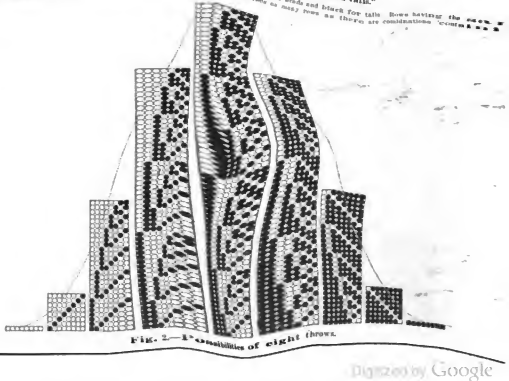

Fig. 2.—Possibilities of eight throws.

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[*] Adapted from Prof. Émile Borel's article in *La Science et la Vie*.

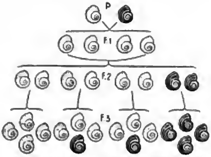


Fig. 7.—Results of crossing plain with striped snails.

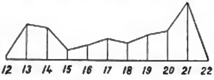


Fig. 10.—Curve representing the number of flower sets of chrysanthemum segetum.

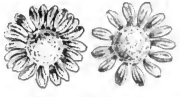


Fig. 12.—Two pure races of chrysanthemum segetum obtained by selection.

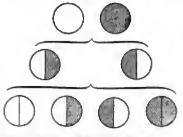


Fig. 4.—Diagram illustrating Mendel's law.

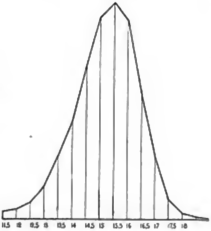


Fig. 9.—Curve of percentage of sugar in beets.

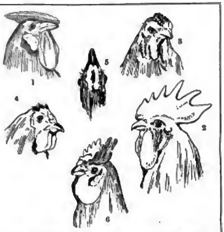


Fig. 6.—Forms of cocks' combs that obey Mendel's law of heredity.

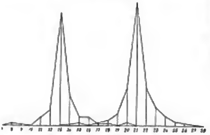


Fig. 11.—Curves of pure races of chrysanthemum segetum.

These characters are called Mendelian if they appear, in successive generations, in the following way:

The crossing of white with black individuals produces hybrids which, in appearance, are like their white parents—a fact which is expressed by saying that the white character is "dominant" and the black character is "recessive." When these apparently white hybrids are crossed among themselves, however, one fourth of the offspring is black. These facts are illustrated by Fig. 4, in which the original pure white and pure black individuals are represented by the top row of circles, the first hybrids by the middle row, and the offspring of crosses of these hybrids by the bottom row. The result is the same as would be obtained by combining in every possible way the white and the black semicircles of the middle row.

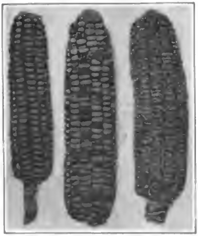


Fig. 5.—Result of crossing smooth and wrinkled varieties of corn.

Just as, when a coin is thrown twice, there are four possible combinations, head-head, head-tail, tail-head, and tail-tail, each of which is equally likely to occur, so when two white-and-black hybrids are crossed, an average group of four offsprings will include one white-white or pure white, one black-black or pure black, and two white-and-black hybrids. As the white character is dominant these hybrids will apparently be white so that, if the observed results are simply recorded without interpretation, the record will show 75 per cent whites and 25 per cent of blacks. The fact that crosses between whites and blacks yield 100 per cent of whites, while crosses between these young whites produce 25 per cent of blacks is certainly very remarkable, and it would be incomprehensible without the explanation given above.

Mendel's laws have been tested by many experiments, especially in the case of plants, from which it is comparatively easy to obtain numerous descendants. Fig. 5 shows two ears of maize, with smooth and wrinkled kernels respectively, and between them an ear of the second cross, with about 75 per cent of its kernels smooth, and 25 per cent wrinkled.

Experiments with animals, continued through many generations, require great care and an extensive establishment. In four years Prof. Rabaud has used more than 30,000 mice in a research that is still in progress. Fig. 6 shows forms of cocks' combs that appear to be transmitted according to Mendel's law. Fig. 7 is a schematic representation of results obtained with snails. The common garden snail occurs in two varities, having respectively plain and striped shells. When these varieties are crossed (*P*, Fig. 7) all of their immediate progeny, constituting the first daughter generation (F_1), have plain shells, as the plain character is dominant Crosses among these young snails (F_1) produce the second daughter generation (F_2) of which 25 per cent have striped shells, and 75 per cent have plain shells. The plain-shelled snails of this generation (F_2), however, are only apparently alike. One third of them (constituting 25 per cent of F_2) produce plain shells exclusively in the next generation (F_3), while the others (constituting 50 per cent of F_2) produce plain and striped shells in the ratio of 3 to 1. The striped snails that constitute the remaining 25 per cent of F_2 produce striped shells exclusively in the third generation (F_3).

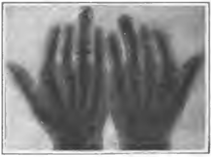
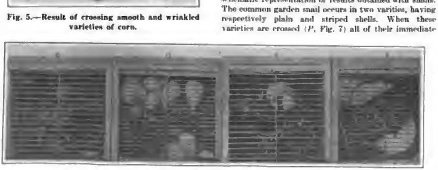


Fig. 8.—Radiographs of hands with abnormally short fingers.

In the course of generations the Mendelian combinations become very complex, especially when the species possesses several characters that follow Mendel's law. These combinations are governed by the same arithmetical laws that apply to the game of "heads and tails," and they may be represented by diagrams analogous to Figs. 1, 2 and 3.

Hence the bell-shaped curve of Fig. 3 is again encountered in the study of heredity.

Mendel's laws may explain certain phenomena of atavism, i. e., the occurrence in a child of characters not shown by its parents but conspicuous in a more remote ancestor. In this way a better understanding of some observed facts may be obtained, but the conclusions that have been derived are based on arguments that are very delicate and sometimes contestable, as Dr. Guyénot has shown. Similar objections apply to theories of sex, regarded as a Mendelian character. For certain malformations that occur frequently in some families the



Some of the cages in which the mice, used in the experiments of Mr. Rabaud, live.

observed facts are not sufficiently numerous to prove conclusively that the malformation is a Mendelian character. An example is furnished by brachydactylism, or shortness of fingers (Fig. 8).

In plants it has been found possible to obtain very definite results, of great practical value, which forecast the results that may be expected from such extensive and well planned experiments with animals as those which M. Rabaud is conducting.

When the statistics of a large crop are arranged with reference to the occurrence of a particular character, the bell-shaped curve of Fig. 3 will usually be found. Fig. 9, for example, indicates the percentages of sugar in a crop of 40,000 beets. The number of beets yielding each percentage is proportional to the height of the vertical line marked with that percentage. This number increases and then diminishes as the percentage steadily increases, and is greatest for the mean percentage, 15.5

In some cases the curve shows two maxima. The Dutch botanist Hugo de Vries, celebrated for his researches on heredity and mutation in plants, counted the flowerets in each flower head of 97 plants of *chrysanthemum segetum*. The results are shown in Fig. 10, in which the height of each vertical line indicates the number of plants which bore flowers containing the number of flowerets marked at the base of that line. The curve shows two maxima, at 13 and 21. The seed of the plants which bore heads of 13 flowerets were collected and sown. The seedlings bore a large proportion of heads of 13 flowerets. By repeating this process of selection regular single-maximum curves were obtained in several successive years. An analogus result was obtained by selecting seeds of plants that bore heads of 21 flowerets. In this way two pure and distinct races, one with 13 and the other with 21 flowerets, were isolated. The curves for these races are shown, partially superposed, in Fig. 11, and typical flowers of the two varieties are illustrated in Fig. 12.

In this instance the isolation of pure races possesses only theoretical interest, but similar methods have been employed with success for the improvement of important agricultural products. One of the most curious cases is that of barley. The modern brewing industry demands barley of uniform quality. The employment of grain of different sorts involves tentative methods and disappointments. The required uniformity has been obtained by selecting seed in the manner described above. This result, first obtained in Sweden, marks the most notable success that has been attained by the application of statistical methods to problems of heredity and demonstrates some of its practical values.

The achievements of such triumphs requires long and patient labor. The statistical theory of biological phenomena is not yet fully developed and it will be many years before all of the results which we are justified in expecting shall have been attained. Meanwhile it appears useful to point out the mathematical resemblance between the problems of heredity and those of games of chance. Mathematicians are sometimes blamed for wasting their energies on problems of no practical importance, and the reproach seems especially well deserved when their researches are devoted to games of chance. We have found, however, that the laws of chance apply to biological phenomena, besides dominating the modern physical theories which are rapidly increasing our knowledge of the nature of matter and energy.

Light Power Excavators

THERE are innumerable small undertakings where earth must be moved, such as sewers, drainage ditches, building roadbeds, and even light dredging, where an ordinary steam shovel cannot be conveniently utilized, and where hand labor is so expensive as to be discouraging. Such work is largely of the kind that is required of township and drainage boards, and a cheap and efficient method for doing this class of excavation not only makes improvements possible in small communities, but encourages such enterprises.

With a view to meeting requirements of this kind the light utility excavator shown in the illustration has been devised, which is operated by a crude oil engine, and is so light that it can be easily handled on any class of work. As the construction is so arranged that the framework can be easily taken apart, the whole outfit can be conveniently transported and set up anywhere by only a few men, and when once located on a piece of work it is self propelling. Besides the nature of the mounting that is arranged to span wide ditches, the chief difference between this outfit and an ordinary steam shovel lies in the fact that a long boom is used, and it is also possible to use a much longer dipper handle; and these differences not only enable deeper excavations to be made, but the excavated material can also be deposited at greater distances on either side. The oil engine power plant is also found much more convenient to operate with the average crew used for this kind of work than steam, and no licensed engineer is required.

The illustration shows the excavator digging a tile trench for drainage, in which work it has proved very economical, and it is also valuable for constructing irrigation canals, and keeping them cleared. Dredging, stripping, construction work and the handling of sand or concrete are other lines of work to which it has been applied.

This machine is light in construction, easily dismantled or assembled, and can be transported on wagons over country roads. It spans the ditch or other excavation or can be mounted on a float. The dredge is of steel construction, and the forward end of the structure is carried on four heavy, double flange steel wheels, arranged in patented swiveling two-wheel trucks. The rear end is carried on two similar wheels, one on either side, loose fitted on axles, allowing ample side play for uneven tracks. The dredges are built to span ditches of various widths and are fitted with special extension axles giving a maximum adjustment of three feet. A suitable number of sections of portable track are employed with each machine.

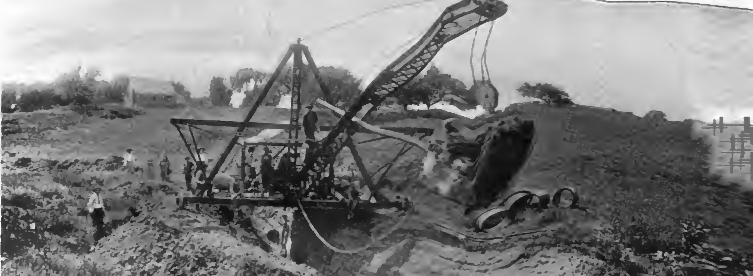
As above mentioned, where the working conditions make it necessary, the entire framework and machinery can be mounted on a float and operated with equal efficiency. The motions of hoisting, swinging, and traveling are operated by friction clutches and controlled with powerful foot brakes. The operating levers are conveniently located in front of the operator, and arranged so one man can easily handle all operating and brake levers without changing his position. The operator stands well forward where he commands a large free and clear view of his work at all times.

It is of interest to note that the power for operating is supplied by an oil engine of proper capacity for operating all motions, either independently or simultaneously. The dipper is constructed with detachable teeth and a quick release bottom dump. The operator has perfect control of the dipper and dipper arm, and very high speeds can be attained.

At Essexville, Mich., one of these oil dredges, having a 32-foot gage, 30-foot boom, one-yard dipper, an 25 horse-power oil-burning engine, was able in a 1[illegible] hour day to handle 600 to 900 yards of dirt with [illegible] gallons of oil.

At another place one of these oil dredges was s up on five pontons each 12 feet long, 8 feet wide, a 3½ feet deep, and it has done some most importa dredging work in a very economical manner.

The Detroit, Bay City & Western Railroad Comp completed about three miles of railroad grade with of these oil dredges, and it is stated by those enga in the work that they could not have built a g through this particular part of the country wit a machine of the kind. The territory covered is [illegible]tically all swamp, and the water stands above top of the ground in many places. They aver about 300 feet of roadbed every 12 hours, and put u embankment each day containing about 600 cubic y Extra help was required in making a runway for dredge, as it was necessary to move most of the on poles or corduroy on account of the extreme ness of the ground.



Light, portable utility excavator operated by an oil motor, shown at work on a drainage ditch.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Power Required to Stop an Automobile

Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In two recent issues of the SCIENTIFIC AMERICAN I note that there have been three solutions of the problem in the July 4th issue, which problem was stated:

"What horse-power would it take to stop an auto in 30 feet running 20 miles per hour and weighing 3,500 pounds?"

In the three solutions above referred to, each varies from the others in the time required to stop the car. It will be noted and admitted by all that this matter of time is the unknown factor in the case, inasmuch as the horse-power required to stop the car in any distance is dependent only upon the time.

I submit the following solution, which agrees with none of the three heretofore published, and yet, without desiring to give the impression of egotism in the slightest degree, I believe this solution to be correct.

SOLUTION.

From the formula $K = \frac{wv^2}{2g}$ we have

$$K = \frac{3500 \times 29.3333^2}{64.32} \text{ or } \frac{3500 \times 29.34^2}{64.32} = \frac{3012924.6}{64.32} =$$

46842.7 *F. P.* of kinetic energy stored in car.

$\frac{46842.7}{30} = 1561.4$ pounds = weight required to stop car in 30 feet.

In order to find horse-power kinetic energy must be expended in a given time, i. e., $T = \frac{D}{0.65v} = \frac{30}{19.064}$ = 1.57 seconds time required to stop car

Therefore, $\frac{46842.7}{1.57 \times 550} = \frac{46842.7}{863.5} = 54.2$ *H. P.* answer.

But $T = \frac{wv^2}{H.P.\,550\,2g} = \frac{D}{0.65v}$. Therefore

$$T^2 = \frac{wv^2D}{H.P.\,550\,2g\,0.65v} \text{ or } T = \sqrt{\frac{wv^2D}{H.P.\,550\,2g\,0.65v}} =$$

$\sqrt{\frac{90587728}{36522419.33}} = \sqrt{2.46} = 1.57$ seconds, approx.

Or $D = \frac{H.P.\,T^2 550\,2g\,0.65v}{wv^2} = \frac{90378257.4}{3012921.0}$ feet approx.

which proves the above theoretically. To prove whole solution note diagram. To construct square as shown, *PORZ*, to any convenient scale, in this case, 1 inch = 1 second per ten miles per hour per 14.6666 feet per second.

Let the line *PZ* scale the vel. in feet per second, and *PO* scale speed in miles per hour.

Since in this case the car traveled 30 feet before stopping, from any point on the line *PZ* lay off 30 feet, say from *d* to *c*. Using *d* as a center with a radius equal to *dc*, lay off *da*, which will be equal to and at right angles with *dc*. Then draw *ac*, which is the base line to the time curve. It will thus be seen from this that the base line of the time curve is dependent only on the distance which the car traveled in stopping.

Since the power applied to stop the car is constant, the decrease in speed will be uniform throughout.

From the formula $T = \frac{D}{0.65v}$ reduce 0.65 to a fraction which is 13/20. Therefore, lay off *ac* into 20 equal parts. Then combine the 20 equal parts into 5 parts with a uniform decrease, which will be 6/20, 5/20, 4/20, 3/20, and 2/20. Therefore, let *ae* equal 6/20 of *ac*; *ef* equal 5/20 of *ac*; *fg* equal 4/20 of *ac*, etc., down, which gives a uniform decrease.

From the points *efgh* just located, drop the lines *gA*, *fB*, etc., perpendicular to *dc*. From *b* on *bc* lay off *bE* equal to *Bc*; *EF* equal to *CD*, etc. Erect perpendiculars at *E*, *F*, *G*, etc., and project *Ae*, *Bf*, etc., until they intersect, which will be at points *i*, *k*, *l*, *m*. Through these points draw the curve *aiklmc*, which is the time curve of the problem with a length of 3.14 inches. Referring to the time scale for 20 miles per hour we find 2 inches = to 1 second of time in time curve. Therefore, $\frac{3.14}{2} = 1.57$ seconds, which is the time it took car to stop as previously stated.

Let *do* equal foot-pound scale equal 46,842.7 foot-pounds. Lay off on *do*, *ds*, *st*, etc., all equal. Therefore, *or* equals 9,368.54 foot-pounds; *ru* equals 9,368.54 foot-pounds, etc. At the points *r*, *u*, etc., erect perpendiculars to the line *od*. Project them until they intersect base line *ac*, which will be at points *s'*, *u'*, *t'*, and *w'*. From these points erect perpendiculars to the line *ac* and project them until they intersect the curve *aklc*, which will be at points *i*, *k*, *l*, *m*.

Then scale *ai*, which, in this case, is 0.314 second. In that interval the car travels from *d* to *o*, which scales 9 feet.

From the formula horse-power $= \frac{K}{T550}$ we have horse-power $= \frac{9368.54}{0.314 \times 550} = 54.2$ horse-power, which proves the above.

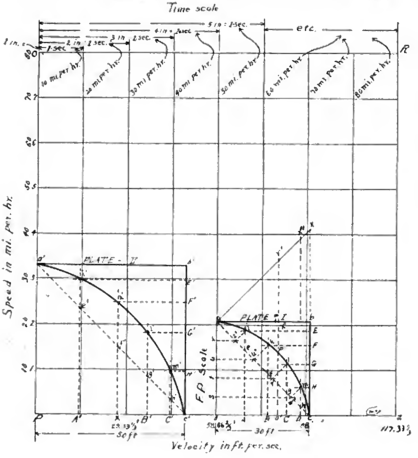
Let *az* = velocity scale, i. e., 29.3333 miles per hour scaled to base line. Angle, *zac* = right angle and *az* = *ac*. Then project *Dm*, *Cl*, etc., until they intersect *az*, which will be at *z''*, etc.

Using *a* as a center, imagine the curve *aklc* swung around until it terminates at *z* instead of *c*. Then *Ai*, *Bk*, etc., would be ordinates of the time curve *aklz*. From the ordinates given, find the mean ordinate, which, in this case, will have a length of *P'o'*. Project the line *P'o'* so that it will lie perpendicular to *ab* and its ends will terminate in *az* and *ab*. Now then, the triangle *r'ax'* = *xr'x'b*, and the mean velocity = *ax'* which scales 13/20ths of *az*, or 19.064 miles per hour. Hence, the formula $T = \frac{D}{0.65v}$. It will be readily seen from the diagram that the mean velocity, and not one half the velocity, or the average velocity, must be used in finding the time.

Note.—Original lines showing projection not left lest diagram be confusing to reader.

Plate II is an illustration of how the time curve would be drawn when the number of feet traveled is less than the velocity. In this case velocity = 60 miles per hour. Distance stopped equals 50 feet. Proceed same as in Plate I. Lay off 50 feet on *PZ* from *P* and also 50 feet on *PO* from *P*. Draw *a'c'* and proceed with time curves same as in Plate I. But velocity = 60 miles per hour. Note time scale, 6 inches = 1 second. Then 6 inches on the curve *a'k'l'c'* would equal 1 second of time.

W. T. FRANCIS.



Magic Squares.

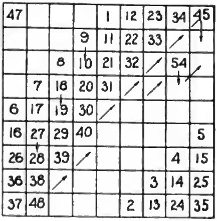
To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

I have been much interested, and so have several other engineers here in the graphic solutions for magic squares as worked out by Mr. A. R. Kennedy in the SUPPLEMENT for October 3rd.

Many years ago I worked out a method by which I could write the numbers consecutively into any square of odd orders, the method being made plain, I think, by the two illustrations given herewith. I did not at that time succeed in evolving a similar method for squares of even order, and have never since had leisure to try it further. Perhaps Mr. Kennedy, or some one else, would be interested in trying it out.

17	24	1	8	15
23	5	7	14	16
4	6	13	20	22
10	12	19	21	3
11	18	25	2	9

Begin always with 1 in top center square. 2 always goes at bottom of next righthand column. Write always to the right and diagonally upward. When the last righthand column has been reached, begin at the lefthand column one row higher. Whenever a multiple of the side of the square is reached drop one space vertically for the next number and write diagonally as before. Variations are, of course, possible.



47				1	12	23	34	45
			9	11	22	33	↗	↓
		8	10	21	32	↗	54	↗
	7	18	20	31	↗	↗		
6	17	19	30	↗				
16	27	29	40					5
26	28	39	↗				4	15
36	38	↗				3	14	25
37	48				2	13	24	35

When once the method is grasped, a magic square of any odd order may be made as fast as one can write the figures.

W. G. SWART.

Mechanical Traction in War

In such ardous work the mortality among the vehicles is heavy, more especially in the case of the German army, which uses a heavier vehicle than is thought advisable elsewhere. The German unit of 4-ton motor truck with 2-ton trailer weighs, when fully laden, about 13 tons—a load heavy to draw on muddy roads cut about by hard service, and dangerous for the smaller bridges and culverts. The difficulty of using such heavy vehicles must grow as the winter comes on, especially in operations on the Russian frontier, where they can scarcely prove otherwise than entirely useless on the primitive dirt roads of the region.

A motor wagon, capable of carrying a net load of 3 tons, will probably weigh, when fully laden, not less than 6¾ tons, and of this at least 4 tons, if not 5, will come on the rear axle. It is necessary, in fact, to expect axle loads of 5 tons. Any road to be capable of taking ordinary motor traffic must be able to stand such a load; even heavier axle loads are supportable, provided the wheels and tires are suitably chosen, but at this point a further factor comes in—viz., the ability of bridges and culverts to carry vehicles of this weight.

In order to enable very heavy vehicles to travel at all on really soft ground it is necessary for them to carry their own track with them. In "caterpillar" tractors, as one class of these vehicles is called, a long band of flat jointed blocks runs around each lateral pair of road wheels; the blocks lie on the ground and the wheels run along a steel race on the inner sides of the blocks. In this way a very large bearing surface is obtainable, but as few of such vehicles have been built there is little experience available as to their durability under the heavy conditions in which they are designed to operate.

The German wagons have been experimented with for all sorts of heavy military work. A simpler way of employing the same principle is the use of what are known as "girdle" plates. These are flat plates of wood or metal girdling each individual road wheel; they were employed on the Boydell traction engine as long ago as the Crimean war, and are now used on some of the heavier German field guns; thus the 11.2-inch Krupp siege howitzer, firing a shell of 760 pounds, is described as being mounted on wheels 6 feet in diameter, having girdle plates attached, so giving a large bearing surface on the ground for the heavy load of 7½ tons which the carriage has to carry when the gun is in the firing posi-

The 16-inch German siege howitzer, of which much has been heard, is stated on good authority to weigh no less than 20 tons, exclusive of its cradle, carri- Now a load of this weight laden on a road vehic- scarcely with the vehicle weigh less than 20 tons. It is difficult to imagine any such load being taken on a road, not so much because of the smashing of the foundations (which might perhaps be avoided by extensive use of the methods above mentioned) as because of the risk of breakage of bridges and culverts. Railway bridges and culverts are able easily to deal with loads far greater than these, and to any point which railways reach there should be little difficulty in carrying these guns; but on roads in general this seems out of the question. But such efforts have probably been made, and later on, when the history of what has been done with motor transport in this war comes to be written, it will be especially interesting to see to what extent they met with success.—*The London Times.*

Mysterious Baalbek

Whose Magnificent Temples Show the Hands of Many Ages and *Nations*

By Mrs. Thomas E. LePage

There is little or no authentic record of Baalbek before the Roman era, yet around and about Lebanon and the Valley of Coele-Syria, the propylaea as it were to Syria proper and biblical history from Baal and Sun Worship to the Sea of Galilee and the Nazarene, have occurred some of the most engrossing events of history. In this scenario, covering over 115,000 square miles and over 2,000 years, Baalbek boldly played a part, as is evidenced in the remains of her splendid temples, the ruins of her palaces and the color of her legends; and while not remote, as distances are measured or dates reckoned, all that remains of Baalbek is a broken seam-scarred city, set apart and unchronicled save in the carvings of her ruined shrines.

From earliest times Syria was an object of prize to the foreign nations without and within her border, and desultory warfare between the tribes made impossible any coalescence of her states. This internal struggle was partly due to her natural environs; the mountain ridges and rivers dividing the country into isolated valleys, plains, and plateaus make a close relationship unnatural and maintain barriers to the adjustment of petty disputes and grievances.

The borderlands are protected from the encroachment of the desert by a continuous chain of lakes and beds of reeds. The Lebanon ranges extend from southwest to northeast in parallel ridges inclosing the valley of the Coele-Syria, that famous plain of Buka'a (mulberry), whose fertile soil has nourished the peoples who despoiled her. Anti-Lebanon, "Lebanon toward the sun rising," begins in the plateau of Bashan and extends north to Mount Hermon, "the tower of Lebanon, which looketh toward Damascus." From Hermon it runs northeast and declines into the plain of Emesa. This range, especially bleak in its scant growth of juniper and dwarf oak, slopes on the west abruptly into Buka'a. Radiating from Hermon on the east are three transverse ridges which form the walls of the terraces. The Phoenician Plain, two miles at its widest, lies at the base of Lebanon on the west. These slopes are cultivated in every crevice of the rock where grow the mulberry and vine, and in the glens below dense groves of olive.

To escape the perils of the Syrian desert the narrow valley became the tramping-ground of conquest, civilization, and trade on its march east and west. Baalbek (ancient Heliopolis) lies off the main roads connecting Damascus with the coast, or with the other cities celebrated in the story of Syria, and this fact accounts in part for the provincialism of to-day. Where the valley opens into the foothills of anti-Lebanon and the plain of Emesa stands Baalbek at the head of that great natural rift that marks the watercourse of Syria. At an elevation of 4,500 feet the city occupies a position similar to that of the Acropolis at Athens. There are the remains of a city wall two miles in circumference, portions of which are of Phoenician origin. Under Alexander the Great the city rose to a high degree of civilization. Augustus made it a Roman colony and placed there a garrison. John of Antioch mentions the Great Temple as built by Antoninus Pius, and names it as one of the wonders of the world. Later it was converted into a Christian church by Theodosius. The temple is said to have contained a golden statue of Apollo, or Zeus, which the citizens would bear about on their heads on certain festival days. There must also have been an oracle of fame at Baalbek, for Trajan is said to have visited it prior to his Parthian campaign.

The Arabs conquered the city in 636, in 1139 and again in 1260 the place was captured by Mongols. In 1400 Baalbek surrendered to Tamerlane on his march from Hums to Damascus, and the city was completely pillaged. From this period the decline was rapid. During the Crusades the city was the scene of constant strife.

The Great Temple was counted a work of Solomon by the inhabitants, and some maintain he built the city as a residence for the Queen of Sheba, but of this there is no historic record. The platform and substructure bear inscriptions, now illegible, pointing to a date earlier than that of Antoninus Pius. Coins of the time of Septimus Severus display a temple with portico and ten columns in front, and another coin has a temple with many columns in the peristyle and steps leading from the side. The architecture on both coins is of the same period.

Syria bears traces of the mythology of Egypt, and Macrobius in his Saturnalia mentions how, in very remote times, priests from On built a Temple to the Sun at Heliopolis in Lebanon, for Sun worship enjoyed high rank at Baalbek. Julia Domna, empress of Septimus Severus, was the daughter of Bassianus, priest of the Sun at Emesa (Hums); and Heliogabalus, a priest of the Sun in the same city, became emperor and assumed title "Invictus Sacerdos Augustus Sacerdos Dei Solis." Worship of Venus also prevailed at Heliopolis.

Under Constantine Christianity was established, and a check was put upon the ancient faith. An imperial rescript was issued warning the people against the excesses of their rites, and admonishing them to accept Christianity. A basilica was erected, and a bishop and his presbyters consecrated. With Julian the Apostate the place again reverted to Baal, and the Christians, banished from Alexandria, were sent to Heliopolis, from where they were distributed to the mines. Theodosius destroyed the temples and fanes and converted the trilothon into a Christian church.

In the seventh century Mohammedanism descended upon Syria, and Damascus, Heliopolis, and other cities became subject to foreign rule. For three centuries following there are no chronicles of Baalbek.

With its appearance the name is changed to Baalbek[1], and the temple was converted into a fortress and used as a defense against the Fatimite Kaliphs of Egypt. Two Arabian chroniclers mention Baalbek in the middle of the tenth century. Ibn Haukal writes in the middle of the tenth century: "Here are gates and palaces, sculpture in marble, lofty columns also of marble, and in the whole region of Syria there is not a more stupendous or considerable edifice." Edrise, an ancient geographer during the twelfth century, mentions the temples and refers to the tradition which regards them as of the time of Solomon. Benjamin of Tudela mentions stones of enormous size laid up without cement.

Of the present-day Baalbek there is little to relate. The few hundred houses are encircled by a wall nearly two miles in circumference. The population is about 2,000 and made up of several religious sects, one quarter being Christian. It is the seat of a Bishopric of the Greek Catholic Church, and contains three churches, four mosques, six schools, and four monasteries as well as a Turkish bath, three hotels and an Arab Kahn.

The quarries lie within a half mile of the ruins, and from them the huge foundation blocks were doubtless taken. The sizes of these can be appreciated by the measurements of a detached block, which is 68 feet 4 inches in length, 17 feet 2 inches wide, and 14 feet 7 inches high, a bulk of 17,000 cubic feet, and weighing perhaps 1,500 tons. In another quarry there is a defective obelisk 98 feet long. The only specimen known to exceed these Baalbek stones is the dolmen at Antequera, measuring in bulk 33,000 cubic feet.

In Syria, where wood was scarce, the native basalt was used extensively in doors, shutters, floors, and roofs, and the technique of masonry became more developed than in any other part of the Roman world.

This famous group of ruins, comprising the Temple of Bacchus, a smaller circular temple to Venus, and the far-famed Temple of the Sun, stands upon a [illegible] acropolis overlooking the town, the Lebanon range and the waterways leading into the Valley of Jordan and the Land of Galilee. The Great Temple, with its mighty sub-basement, subterranean vaults that [illegible] the half the city, the immense courts, propylaea [illegible] steps unexampled in the history of ancient architecture are of solidity and proportion that [illegible] prophesy the destiny of races and the [illegible] nations. In plan and decoration the Greek and [illegible] dominate, although many ages have contributed [illegible] directly.

While dependent upon the Greeks and [illegible] their principles of architecture it was left [illegible] principles of [illegible] engineering to supply the [illegible] problems such as [illegible] to the more complicated [illegible] of dome, vault, and arch. Here the [illegible] spans exceeded [illegible] in the [illegible] the only other genius of the Great Temple, the only other being the Temple vaulting on so large a scale. The beautiful forecourt, flanked [illegible] of which [illegible] the Great Court, where stands the [illegible] and [illegible] the Sacrifice and the Basin of Lustration, [illegible] leads [illegible] Theodosius' basilica, and only recently [illegible] Burnt by [illegible]. This court is also flanked by a series of halls varying in size, and once ornamented [illegible] carving [illegible] statues. The Temple of the Sun is approached [illegible] stairs leading from the west side of the [illegible]. This temple, covering an area of four acres, w[illegible] encircled by a peristyle of fifty-four columns [illegible] tunlly [illegible] six alone in the southern rank are st[illegible] which [illegible]. These shafts measure 60 feet in height, are 7½ f[illegible] diameter, and are constructed each of three block[s] rough unhewn stone, the Romans invariably using [illegible] fluted column when the material was not granite or porphyry. The capitals and entablature are richly carved with acanthus leaves. A frieze of lion's heads, a cornice and molding complete the architrave; and it is here that the Roman offends in the redundant display of Corinthian ornature, overstepping in his application of decorative art the standards of taste that the Greeks have established and devotedly observed.

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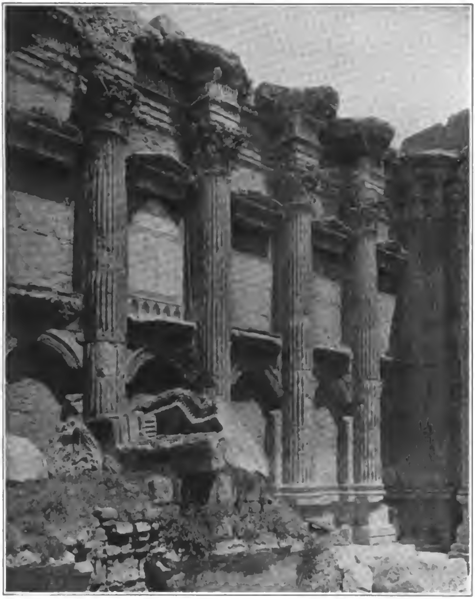
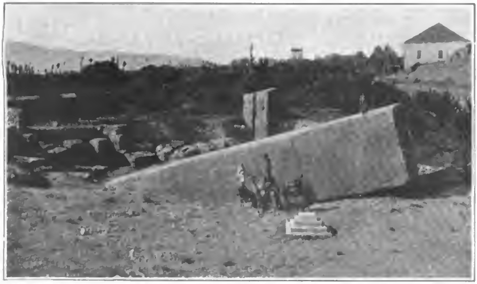
[1] The probable etymology would read:

[Baal, god of Sun = *Helios*, lord of Sun: + bek < Ar. Bakka, compressed, thronged = Baal's throng or place of gathering].

A second etymology which has been suggested [*bek* < Egyptian Bakl, city] accords with Heliopolis, but the admixture of foreign tongues is without analogy. The Frank historians write it Malbec.



Interior of the Temple of Bacchus at Baalbek. Note tablet to the German Emperor.



Immense monolith lying in a quarry at Baalbek. Similar stones were used in the foundations of the temple.

Great court in the temple in which sto

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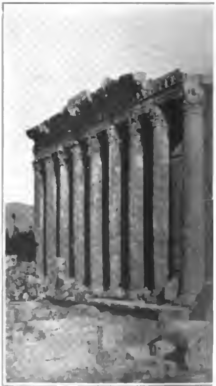

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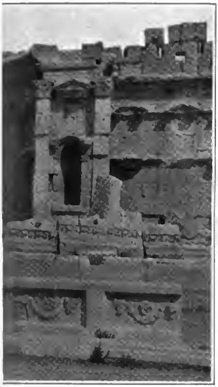

to the Sun, and the Basin of Lustration.

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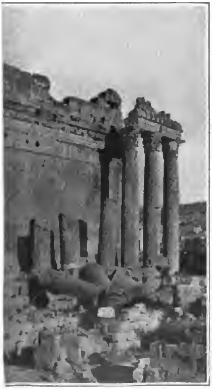
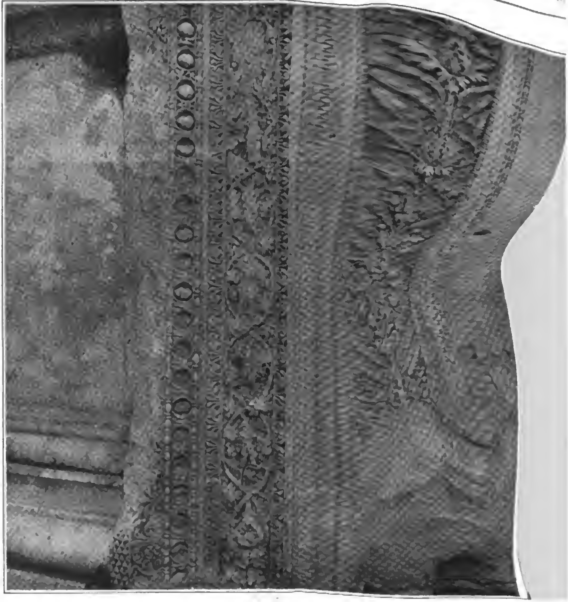
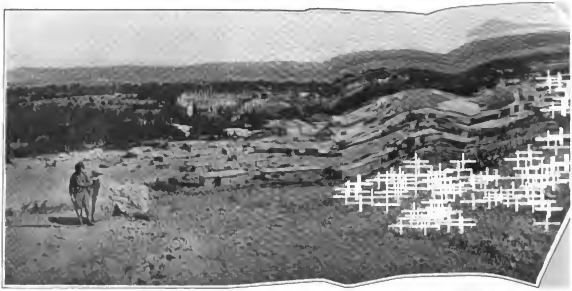


Bacchus.



Richly carved portal of the Temple of Bacchus.



General view of Baalbek, with the great ruins beyond. The Lebanon ranges of mountains are seen in the distance.

Every member of the decoration of the temple suggests a function, and is least elaborate where the strain is greatest. But it is in the interior of the Temple of Bacchus where the zeal of the artists runs riot in such a mass of ornate detail that one sighs for the works of Ictinus and the chaste columns of the Parthenon.

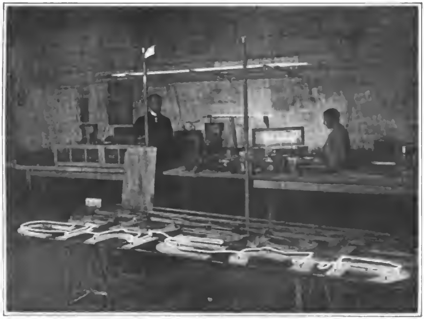
In the north wall of the Bacchus interior the inscribed tablet recording the German Emperor's visit to Baalbek is plainly visible.

The arcading, in which the Roman excels, is exemplified in the circular Temple of Venus, a form borrowed from the Etruscans. This example is noticeable for its pentagonal bases, four-columned portico and the heavy entablature of Corinthian ornament overhanging carved architraves. There is the usual peristyle of columns added by the Romans, a distinctive departure evidently regarded as an improvement.

The mythology of Syria is the history of an intensified and prolific age in which parthenogenesis was the impelling idea. The fish, symbol of progeny, is the popular emblem. It has been said that in Greece "the myths are luminous, harmonious, in Egypt maintaining an appearance of wisdom even when most fantastical," but in Syria "they seem to whirl as the simoon of the desert."

Three impressions remain after reviewing these monuments: First, the sense of solidarity and proportion expressed in the massive masonry; second, the ravish display of Corinthian ornature, so luxuriant, sumptuous, sensuous in its exquisite beauty of concept and form that the eye were pained and the mind repelled did not there come lastly that charm ineffable, the secret of Sun worship. A gorgeous burst of purple flame and gold, softly, swiftly, triumphantly, immaculately sweeping that broken pile, the historic record of many races.

Making long neon tubes.



Making electric and photometric measurements of neon tubes.

Neon Light Tubes

By Jacques Boyer

A PECULIARLY striking example of the fruitfulness in practical results which is attached to scientific researches carried on primarily from a purely academic interest is presented by the case of neon. This gas was first recognized as one of the constituents of the atmosphere by Ramsay. It will be remembered that his classical researches had their inception in the observation that atmospheric nitrogen had a slightly greater density than nitrogen prepared from other sources. Hence an impurity was suspected in atmospheric nitrogen, and systematic investigation did reveal such an impurity in the so-called "rare" gases of the atmosphere, which constitute about one per cent of its total volume.

Now these rare gases, one and all, have a peculiarity that at first sight would seem to render them ill adapted for practical uses; they are exceedingly inert, and utterly refuse to enter into any chemical combination. It appears hopeless, therefore, to expect any use for them except in their elementary form.

Yet one of them, neon, does possess physical properties which render it peculiarly adapted for a specific use: A "vacuum" tube, the residual gas of which consists of neon, has been found by the French physicist Claude to offer a peculiarly low resistance to the passage of an electric discharge therethrough; on this basis an electric lighting system of high efficiency has been developed.

The neon is obtained in a state of great purity by fractional liquefaction of air, of which it constitutes one part in sixty-six thousand Using a liquefaction plant having a working capacity of 50 cubic meters of liquid oxygen per hour, 10C liters of neon can be obtained per day, and this is sufficient for the manufacture of 1,000 neon tubes of 1,000 candle-power each

One of the principal difficulties encountered in the manufacture of neon light tubes is the fact that mere traces of nitrogen and especially of hydrogen very materially reduce the luminosity of the tubes.

This difficulty has been overcome by taking advantage of the phenomenon discovered by Dewar, that charcoal is extremely efficient in absorbing gases near their point of liquefaction. A bulb containing such charcoal and cooled with liquid air is made part of the system to be filled with neon at low pressure, and, after it has done its duty, is fused off, thus leaving the neon tube practically free from objectionable impurities.

M. Claude has succeeded in preparing neon tubes some 17 feet in length, which have had a life of 1,000 hours, thus equaling the best incandescent lamps. The tubes can be made in any desired shape, to follow the contours of the space to be illuminated.

Neon light has a beautiful pink color, and it is totally devoid of blue rays. For this reason blue objects appear black in neon light, and to overcome this it is necessary to combine it with incandescent or mercury vapor light where true color values are desired.

One ampere gives about 900 candles in a neon tube 6 meters long, at a rate of 0.72 watts per candle.

Inserting the copper electrodes into the ends of the tubes.

Charles William Eliot

President of the American Society for the Advancement of Science

By Marcus Benjamin, Ph.D.

In no department of learning has the development of knowledge in recent years been more conspicuous than in education. This is especially true in the United States. A greater knowledge of science has also come about in consequence of improved educational conditions. Appreciative of these facts, the American Association for the Advancement of Science created in 1906 a special section of education, and at the meeting held at Atlanta, last December, gladly called to the highest office in its gift America's foremost educator.

Charles William Eliot was born in Boston, Mass., on March 20, 1834, and was the only son of Samuel Atkins Eliot, and Mary Lyman Eliot. His father was a well-known importer in Boston, of which city he was also mayor in 1835-37, and his mother's father was a successful merchant in the East India trade.

His early education was received at private schools, from which, at ten years of age, he was transferred to the Boston Public Latin School, then under the direction of Epes Sargent Dixwell. Ten years later he entered Harvard with the class of '53 and graduated in due course, standing second in his class.

In the winter following his graduation, he returned to Harvard as tutor in mathematics, and with his classmate, James Mills Peirce, who had received a similar appointment, began a life-long work as an educator, President Walker having urged upon him "to aim at the career of a college teacher." He was promoted to an assistant professorship in mathematics and chemistry in 1858, and two years later was given charge of the chemical laboratory of the Lawrence Scientific School, where he remained until the summer of 1863.

Two years abroad followed with periods of study in England, France, and Germany, during which he devoted special attention to the organization of technical schools and the prevailing methods of teaching chemistry and physics. It was by this experience that he unconsciously fitted himself for the acceptance of a professorship in chemistry in the Massachusetts Institute of Technology, then recently organized, to which he was called in 1865 by William B. Rogers, its founder and president. Here he remained for five years, organizing and developing the chemical department of that famous institution. Those years will never be forgotten so long as his Manual of Inorganic Chemistry (1866) and his Manual of Qualitative Chemical Analysis (1869) are used as text books, while his epoch-making influence in the study of chemistry will continue for all time.

The valuable results achieved during his connection with the Massachusetts Institute of Technology gave him a high reputation both as a teacher and as an administrator, while his articles in the *Atlantic Monthly* on The New Education clearly demonstrated that a new power had arisen in the domain of education. The selection of the Board of Overseers of Harvard had long been vested in the state legislature, but in 1865 that function was transferred to the alumni, and it was believed that the time had come when the curriculum could be improved. In 1869 Mr. Eliot was elected to the presidency of the Alma Mater in succession to Dr. Thomas Hill, and so continued until 1909. He at once began a series of changes that have supplanted the old-fashioned prescribed course of study by an elective system, until more and more Harvard has come to resemble the great European universities.

Of these changes he says: "For the first 20 years progress was made through continuous struggle against the resistance of many wise and honorable persons, both within and without the university," but thereafter "there was much less conflict; because the ideals of the group of active workers to which I belonged became the ideals of a considerable majority of the friends of the University." The details of the progress cannot be given here, but they may be seen in the annual reports made by him as president of Harvard College to the Board of Overseers, the first of which was presented in 1870, and the last in 1909 for the years 1907-08. These it is said "have ranked among the most valuable contributions to the literature of higher education."

Seldom indeed has it been given to any man to so successfully achieve the ambitions of his earlier years.

As years have come to him, public recognition of the good results of his labors have been his. Williams and Princeton in 1869, Yale in 1870, Johns Hopkins in 1902, Tulane, Missouri, and Dartmouth in 1909, have given him the degree of LL.D., and Breslau in 1911 conferred upon him the degree of Ph.D. His own Harvard, on his retirement in June, 1909, not only crowned his faithful labors with the doctorate in laws, but bestowed upon him the annual honorary doctorate in medicine "for his persistent, powerful, and courageous help in accomplishing the extraordinary reforms in medical education." Nor have foreign nations failed to recognize his educational work. In 1903 France conferred on him the insignia of an officer of the Legion of Honor. A year later he was made a corresponding member of the French Academy of Moral and Political Sciences. In 1908 he received the insignia of Grand Officer of the Crown of Italy, and in 1909 the Royal Order of the Prussian Crown, and the Imperial Order of the Rising Sun of Japan, these three decorations being all of the first class.

His wonderful gift of lucid statement and persuasive eloquence has naturally led to his being in demand for public educational and scientific addresses, and conspicuous among these may be mentioned the one made at the installation of Daniel C. Gilman as president of the Johns Hopkins University, and the one at the opening of the American Museum of Natural History in New York. While these addresses have been largely, as he says, of "an ephemeral nature or related to some question which was temporarily interesting the community or the institution where I was speaking," nevertheless they have had a mighty influence on molding public opinion, for his utterances were the result of deep thought and therefore carried conviction with them.

Copyright by Marceau.

Charles W. Eliot,

President of the American Society for the Advancement of Science.

In the United States his interests in various organizations has always been sought and there are but few of which he has not been a member. His name is among the fellows of the American Academy of Arts and Sciences, and he is also a member of the Massachusetts Historical Society. The American Philosophical Society, the oldest scientific organization in this country, has long had his name on its rolls, while the National Education Association of the United States and the National Conservation Association have been fortunate in having him as their president.

In addition to those already mentioned, his printed writings include the following books: Five American Contributions to Civilization and other Essays (1897); Charles Eliot, Landscape Architect (1902); John Gilley (1904); The Happy Life (1905); Four American Leaders (1906); and The Durable Satisfaction of Life (1910). These have been contributions to discussions which were of importance at the moment and not likely to be of permanent interest. Of them he writes: "Three of my books—two very small—may have some durability: The Happy Life; John Gilley, and Charles Eliot, Landscape Architect."

Since his retirement from the presidency of Harvard University, he has continued to work for certain public interests closely related to each other, which have long engaged his attention and which he believes to be of fundamental concern to democratic society. He [illegible] of them: "The chief of these interests are education, civil-service reform, municipal reform, capitalism and unionism in a democracy, preventive medicine, and conservation. They all relate to the building up, under free institutions, of sound character in the individual citizen and in the nation." The most conspicuous of these undertakings was perhaps his trip around the world during 1911-12 in the service of the Carnegie Endowment for International [illegible], and the fruits of which were given to the world in 1914 under the title of "Some Roads Toward Peace," being a report to the trustees of the Endowment on observations made in China and Japan in 1912.

His connection with the American Association is of recent date, for he does not appear to have joined the organization until the third Boston meeting in 1880, but his powerful influence soon made itself felt and the Association promptly availed itself at the earliest opportunity of recognizing his high standing by electing him its president.

Quick Mending of Broken Bones

Within the last few years several important methods of handling fractures have been announced that have greatly shortened the time required for the knitting together of the fractured parts resulting in more rapid recovery from this class of accidents; and it was only recently that what was considered a wonderful improvement was made public by the process of joining the ends of a fracture by means of a splint of bone that not only spliced the parts together, but supplied a nucleus for the formation of new material that would make a permanent union. This operation, however, necessitated an incision, and considerable work on the bones themselves. Now another method of treating fractures has been announced by Dr. H. J. Kauffer, a New York dentist, and consulting oral surgeon to the Harlem Hospital, which promises to produce wonderful results, and it can be applied in many minor but important cases, where it would be difficult to use other of the newer methods. In Dr. Kauffer's process he dries and grinds to powder a piece of fresh bone, and this powder he mixes to the consistency of a paste with petrolatum, and properly sterilizes the mixture. After the ends of the fractured bone have been brought into proper relations and the location ascertained by digital examination and X-ray, a syringe having a long needle is filled with the warmed bone mixture, and the needle is inserted to the seat of the fracture, and as deeply as possible between the fractured ends. The contents of the needle are then injected as the needle is slowly withdrawn to the surface of the bone, when the injection must stop. This procedure may be repeated several times at different angles, thus filling the [illegible] space between the fractured ends with the petrolatum and bone cells, which act as a form for the formation of new bone. The powdered bone and petrolatum is recommended wherever bone is required. The powdered bone is stated to invite calcareous deposits and [illegible] the transformation of adjacent tissue cells [illegible] bone. The announcement of this new method of procedure, which is made in the New York Medical [illegible], is but a brief advance notice, and the [illegible] paper giving results attained will be looked for with interest.

Effect of Impurities in Zinc

It has long been known that impurities, such as [illegible] in zinc, greatly affect the ease with which it can be rolled, and from a series of experiments recently made in Europe it appeared that cadmium is harmful if there are 0.25 per cent, while with 0.5 per cent rolling is [illegible]. Arsenic, 0.02 per cent, markedly increases the hardness, and with 0.03 per cent the metal is too brittle for practical purposes. Antimony is objectionable, [illegible] than arsenic, as 0.07 per cent does increase the hardness; but 0.02 per cent is enough to produce a striated surface on the rolled sheet, which makes it unsuitable. Tin is objectionable when over 0.01, and [illegible] it reaches 0.08, and with 0.19 per cent. the zinc is unworkable. Copper does not harden until [illegible]. A permissible maximum of iron is 0.12 per cent, but this is easily reduced in refining. Though 1 to 1.25 per cent of lead does not interfere with the rolling, a slight increase not only seriously affects the malleability, but the excess of lead remains unalloyed and forms patches on the sheet. The presence of two or more impurities together results in a combination of the injurious effects of each.

Artificial Daylight—II*

Light Sources Suitable for Color-Matching

By Herbert E. Ives

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2033, Page 398, December 19, 1914

THE PRACTICAL ACHIEVEMENT OF ARTIFICIAL DAYLIGHT.

BEFORE proceeding to an account of various artificial daylights let us here review briefly the pertinent facts about daylight and color. We have seen that daylight is variable, but that it always lies in a class apart from the usual artificial light sources, which latter are in general of a yellow color. We have seen how color may be exactly measured, and have learned that the same color appearance may be produced in several ways. Several theoretical ways of producing artificial daylight have been described. Finally, by investigating the changes in the apparent color of objects under different colors of light, we have been led to formulate the essential characteristic of artificial daylight; namely, it must not only look like daylight, but also be like it, as shown by an analysis of the spectrum.

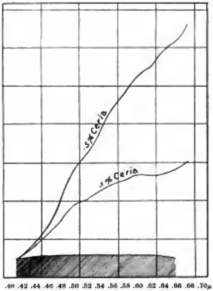


Fig. 11.—Typical Welsbach mantles compared spectrophotometrically with daylight.

In approaching the practical side of the problem it becomes necessary to choose a standard for daylight, and it becomes necessary to know what degree of approximation to the last-named criterion is sufficient for practical purposes. It is also necessary to pay attention to the matter of efficiency—the artificial daylight must not be prohibitive in cost.

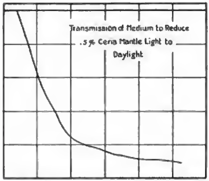


Fig. 14.—Transmission of medium to reduce light from 0.5 per cent ceria mantle to daylight.

The standard of white light adopted by the writer is derived from the mean of a large number of spectrophotometric determinations of sunlight quoted above, into which an additional factor has been introduced. It is always desirable to connect any standard with other standards; to depend not on a set of numerical values, but on some simple mathematical expression which may be developed by the introduction of a few constants. It appears, for instance, that the white light standard mentioned has to within the limits of accuracy of its determination the distribution of intensity through the spectrum of a perfect incandescent solid or black body at 5,000 deg. Cent. absolute; a distribution immediately calculable from the laws of black body radiation. So much for a scientific standpoint. In commercial practice another fact has had to be given weight; namely, professional color matchers have chosen as their standard light the blue north sky. It is difficult to change the customs of experts, and so it became practically necessary to supply a blue sky standard. For this the spectrophotometer values given in Fig. 2 serve as a basis.

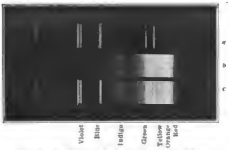


Fig. 9.—Additive production of artificial daylight.

a, Mercury arc spectrum; b, tungsten lamp spectrum; c, combination of mercury arc and tungsten lamp light to make a white light.

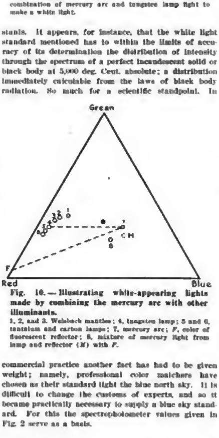


Fig. 10.—Illustrating white-appearing lights made by combining the mercury arc with other illuminants.

1, 2, and 3. Welsbach mantles; 4, tungsten lamp; 5 and 6, tantalum and carbon lamps; 7, mercury arc; F, color of fluorescent reflector; 8, mixture of mercury light from lamp and reflector (M) with F.

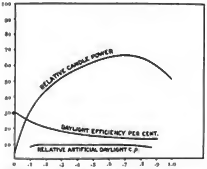


Fig. 13.—Total efficiency calculations for mantles of various compositions.

How closely is it necessary in practice to approximate the exact spectrum distribution of daylight? Very closely indeed, but not so exactly as to be prohibitively difficult, for this reason: that all ordinary colored objects and coloring materials have rather long diffuse spectra; they are not isolated, sharply defined spectrum colors. Consequently, if such gaps and irregularities of the artificial daylight spectrum are bridged over by the reflection spectrum of the color illuminated, they will not be noted. For instance, an illuminant whose spectrum consisted of twenty-five or thirty equally spaced lines would probably behave excellently as a color-matching light, provided, of course, their intensity was closely that of the daylight spectrum at each point. An expert with a knowledge of the spectrum and of the kind of coloring media used in the arts can make up critical colors having several maxima of reflecting power in the spectrum, colors which match under one light but not under another, and from the accumulated experience of the practical dyer other colors may be found of similar difficult character. The behavior of these colors under an artificial daylight in its experimental stages provides valuable information and guidance.

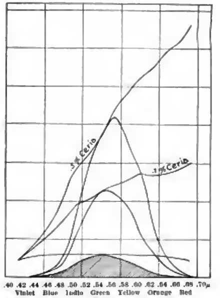


Fig. 12.—Calculation of daylight efficiencies of different mantles.

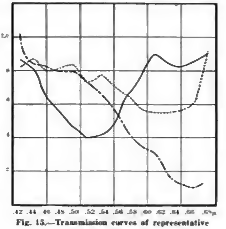


Fig. 15.—Transmission curves of representative glasses and dyes.

The question of efficiency will be considered in connection with each of the three kinds of artificial daylight described below.

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*Paper read before the Franklin Institute and published in its Journal. Copyright, 1914, by the Franklin Institute.

The first kind of artificial daylight postulated as possible is a light source that has naturally the same spectrum distribution of intensity as daylight. An incandescent black body at 5,000 deg. Cent. absolute would have this distribution, but such a temperature is entirely beyond our present means. The same distribution could be obtained at much lower temperatures if we had available a selectively radiating substance which would give out a comparatively small amount of invisible heat radiation and have a much greater emissivity at the blue end of the spectrum than at the red. Such a substance is not yet known, but the materials used in the Welsbach mantle approximate the characteristics to a degree which incites us to further study of these oxides. Another possible way of achieving this spectrum distribution is through non-temperature radiations, as, for instance, by the passage of a current of electricity through a rarefied gas which would radiate at a sufficient number of wave-lengths in the right proportion. Such an artificial daylight has been found in the radiation from the carbon dioxide vacuum tube, which under the name of the Moore tube has been developed commercially and has deservedly been used to considerable extent for color-matching work. Its spectrum consists of many fine lines and bands, together giving the color of a light blue sky and of reasonable uniform intensity. The Moore tube is, however, comparatively inefficient, and demands an expensive installation of alternating current and transformer to produce high potential—drawbacks which have prevented its extensive use.

The second kind of artificial daylight I wish to treat of here is one of interest from the standpoint of color measurement and theory. So far as concerns the question of color matching, this particular daylight—namely, the one made by matching pairs of colors to look like daylight—is chiefly of importance as illustrating the pitfalls to be avoided.

A property of the color triangle above referred to is that colors lying on opposite sides of a line passing through the center of the triangle (white) mix to produce all colors lying on that line, among them white. Consequently, if two happen to lie thus on opposite ends of a line through the center of the color triangle, it should be possible to make a white-appearing mixture. Examination of the color triangle, Fig. 10, shows that the mercury vapor arc lies opposite the tungsten lamp. Consequently, if these two illuminants act together the appearance should be that of white light. Such is, in fact, the case. White-appearing light can be so produced at an efficiency somewhere between that of the two constituents, and white light of this constitution is to be found in several places. The term "additive" production of artificial daylight may be applied to this process to distinguish it from the other process presently to be described as "subtractive." This particular "additive" daylight, and others which are apt to be produced experimentally in efforts to make a true artificial daylight, are characterized by their failure to show up colors in their true daylight appearance. The reason for the failure of this particular combination is easily seen from the spectrograms of Fig. 9, where the tungsten lamp spectrum is shown, with its deficiency in blue; the mercury arc spectrum, deficient in red, and the combination of the two. The latter is characterized by long gaps and irregularities. The mercury arc-tungsten combination is not, therefore, suited for one use to which it has been mistakenly put; namely, the illumination of picture galleries.

Another example of this additive method of producing white light is furnished by the Cooper-Hewitt lamp with fluorescent reflector. The fluorescent substance—rhodamine—is of a color approximately complementary to the hue of the mercury arc, as is shown in the color triangle of Fig. 10, where the fluorescent light is shown at *F*, the mercury arc at 7, and the "white" light at S.

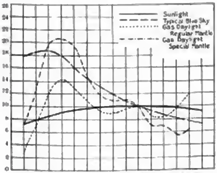


Fig. 17.—Spectrophotometric curves of natural and artificial daylight.

This is not exactly on the line joining 7 and *F*, because the mercury arc light reflected from the rhodamine reflector is deficient in green. The real mixture is between *F* and *M*. It will be seen that the resultant color is a purplish-white (below center of the triangle). This light is, unfortunately, not suited for delicate color matching, because its spectrum is merely the mercury lines with an orange-red band added. Large portions of the spectrum are missing.

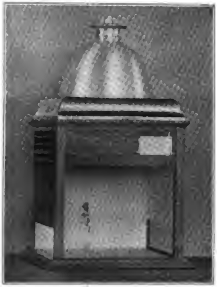


Fig. 16.—Color-matching booth.

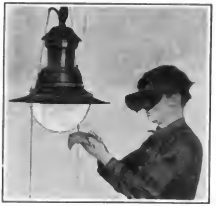


Fig. 18.—Manner of using daylight spectacles.

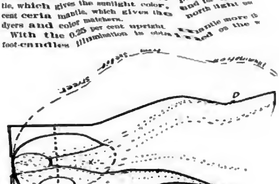
The next, and on the whole the most important, method of producing artificial daylight is the subtractive one; that is, the subtraction by absorption of those radiations which an illuminant emits in excess over daylight.

By way of detailed explanation let us now carry through the various steps in the practical production of such an artificial daylight. Let us take as our illuminant to be transformed to daylight the Welsbach mantle, which, because of its nearer approach to whiteness than the usual incandescent solids, especially recommends itself for the purpose. The first step is to determine its distribution of intensity throughout the spectrum and compare it to that of daylight. At once cognizance must be taken of the fact that the color (intensity distribution) of a mantle depends upon the composition. A pure thoria mantle is much whiter than a mantle of pure ceria, the light of the latter being, in fact, deep orange-yellow. Fig. 11 shows the energy distribution of two typical mantles, containing 0.25 per cent and 0.50 per cent ceria respectively, each compared with daylight under such conditions that the intensity at the extreme blue end of the spectrum is equal. When these data are so plotted the space between the mantle curves and the daylight curve represents light which must be absorbed. It is obvious that the whiter the mantle (i. e., the smaller the percentage of ceria) the less light must be absorbed in order to leave daylight. As yet, however, the amount of this absorption is not expressible in useful comparative units. It is necessary to express this in terms of luminosity. This is done by replotting the data of Fig. 11, multiplying the value at each wave-length by the relative brightness of that kind of radiation as is done in Fig. 12. Now the area of th "white" luminosity curve, compared to the area of th mantle curve, gives us at once the relative amount light left after the subtraction process. This ratio have called the "daylight efficiency." Its value for mantles of various percentages of ceria is plotted at curve a, Fig. 13. Other things being equal, it is clear that the mantle with no ceria should be chosen. But other things are not equal, for with varying percentages of ceria the candle-power of a mantle changes, rising from a minimum for the pure ceria to a maximum for a mixture of 99 per cent ceria and 1 per cent of thoria, then again decreasing as the ceria content is increased. This curve of relative candle-power is also shown in Fig. 13. It is obvious that the product of curves a and b will give the total daylight efficiency of all mantles when screened to make artificial daylight. This product is shown in curve c interesting, as showing that mantles through quite a range of composition—from 0.25 per cent to 0.7 per cent ceria—can yield the same efficiency of artificial daylight. Above 0.7 per cent ceria the efficiency drops off rapidly. This efficiency is only about 15 per cent, showing that artificial daylight is necessarily an expensive product when thus secured.

Having chosen a mantle to be screened, the next question is that of absorbing media. What is the absorption needed? Putting it in terms of transmission it is this: The transmission at each wave-length must be the ratio of the daylight intensity to the artificial light intensity when so represented that the value is unity for the extreme end of the spectrum. The transmission required to transform the light of the Welsbach mantle of 0.5 per cent ceria to "white" (black body at 5,000 deg. Cent. absolute) is shown in Fig. 14. It appears that the absorbing medium indicated is of general blue color. The next step is to study the various available absorbing media. These are practically reduced to two: first, colored glass, and, second, dyes which may be incorporated in gelatine or some similar transparent carrier. No single glass or combination of glasses at present on the market possesses the absorption called for. Cobalt blue glass, which is the first thought of everyone, has several irregular bands, not a uniformly increasing transmission toward the blue end of the spectrum. Copper glass, which is blue-green in color, has a gradual absorption, but is too green. The great advantages of glass over dyed gelatine are its permanence and the possibility of working into all shapes, from flat sheet to spherical enclosure. Still, dyes have the one advantage that they provide an enormous number of absorptions of both broad and narrow types. Some representative transmissions are shown in Fig. 15. The bands and deficiencies of glasses can almost always be filled in by properly chosen dyes, although many dyes are not at all permanent, which reduces very materially the number available.

It has been found possible to make a practical combination of copper glass in sheet form with a dyed gelatine layer on a separate sheet, which accomplishes th purpose admirably, using dyes of great permanenc The commercial device is shown in Fig. 16. It consis of a small booth, closed at back and sides, in order th stray light from other light sources may not enter a mix with the daylight. Samples of cloth, tobacco, e are held under the glasses, and the result is ident with daylight. The spectrophotometer intensity c is shown in Fig. 17, both for an 0.7 per cent ceria tle, which gives the sunlight color, and for an 0.2 cent ceria mantle, which gives the north light u dyers and color matchers.

With the 0.25 per cent upright mantle more th foot-candles illumination is obtained on the w



Street
D
K
A
Oblong Spot of Sunlight on Floor
Illumination from Sky Patch of Window S

Fig. 19.—The distribution of dayl window.

plane, while with a large inverted mantle the figure is multiplied by four—in either case sufficient for color-matching purposes. The absorption of light by the glasses is about 90 per cent. The device has been worked out in the booth form partly because the expense of lighting large areas would be excessive, were there not some good reason for so doing, which often there is not, and partly to educate the user to exclude stray light of other colors which would distort his color values. These devices are now being used extensively in silk mills, cigar factories, department stores, etc.

A limitation to this form is its lack of flexibility, caused by the necessity for using dyed gelatine, which can be laid down only on a flat plate. The extreme desirability of effecting the entire absorption through glass has long been apparent, and in the Research Laboratories of The United Gas Improvement Company a small experimental glass plant has been actively engaged in the problem of producing such glass. All known coloring oxides have been studied, and Mr. Edw. J. Brady, in charge of this particular research, has recently succeeded in producing a true daylight glass. This glass will shortly be available for gas and other illuminants, and will make artificial daylight as easy to produce as any other artificial light—necessarily at a large cost, to be sure; but in many cases this large cost will be an insignificant item compared with the twelve or more additional working hours furnished by artificial daylight.

Before leaving this subject of the production of light having a daylight color, one of the methods of using the absorbing medium claims attention. Colored objects, it must be remembered, owe their color to the effect on the light incident upon and reflected from them. Now, it is immaterial whether the light is subjected to the day-color producing absorption before or after its incidence on the colored object. Except for considerations of convenience, the absorbing glasses could just as well be placed vertically in front of the booth in Fig. 16, and the colored samples placed in the direct light of the illuminant. Advantage is taken of this alternative possibility in the construction of the daylight spectacles, shown in Fig. 18. Built with a perfectly light-excluding hood, these may be worn by the surgeon or the color matcher, and when used with the appropriate light source they produce daylight for him alone, thus obviating the necessity for a special booth or room in which to do his work. Further advantages of this form of color-matching device are the small amount of special glass needed and the entire freedom from questions of breakage through overheating.

THE COST OF A COMPLETE COPY OF DAYLIGHT.

The question always asked about artificial daylight is: How much does it cost to make a complete copy of daylight illumination in a room? Some figures which I have given elsewhere in connection with a study of the distribution of daylight may, therefore, be of interest here. Pleasant daylighting of the room taken for study, a room 16 feet by 10 feet, was produced when the light of the sky illuminated the whole floor of the room and when the ceiling was illuminated by the light reflected from the street below, while the opposite houses, which were in shadow, were the only outside objects visible to the occupants of the room. The bright sky, which does most of the lighting of the room, forms a concealed light source. The distribution of light from the window as a light source is shown in elevation in Fig. 19. It was found possible by a construction of mirrors to closely duplicate this distribution and to produce an illumination about one tenth that of real daylight at an expenditure of about 200 watts. To secure daylight intensity would have taken 2,000 watts, whereas if the light had all been subjected to daylight-producing absorption it would have required 20,000 watts.

If, however, daylight could be produced directly in an illuminant without any waste heat radiation, it would not only be a much more efficient process than that indicated, but even more efficient than any present known artificial light source. Instead of 20,000 watts, 50 watts would suffice.

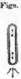
The ultimate goal of the student of artificial daylight, therefore, is the production of daylight whenever and wherever it is wanted, distributed in any desired manner, at no greater cost than our present yellow artificial light.

The Absorptive Power of Myelin Liquid Crystals

By B. O. Lehmann

The growth of the "apparently living" myelin crystals is, as I have already shown, in no way related to that of Traube's artificial cells, where increase in size is due to internal osmotic pressure of the contained fluid. Indeed, the myelin forms are in general solid, containing no foreign fluid. Furthermore, I have proven that even the hollow myelin forms of phrenosin and protagon do not grow by osmosis, increasing as they do equally well when open at one end as when entirely closed. When open they elongate by the swelling due to the taking up of water molecules into loose chemical combination, and hence suck water into the lumen on the same principle that a bicycle pump sucks in air. Sudden shortening, due to lowering of temperature, ejects a corresponding amount of water (Figs. 1 and 2). In the same way a hollow myelin form may suck in and throw out one or more smaller forms.

The discovery of this absorptive power gives the long-sought explanation of the origin of the long thread-like and tubular myelin shapes arising when a substance swells in a liquid in which it is insoluble. For example, allow a thin film of phrenosin to dry on a slide, then introduce fresh water under the cover glass. First wart-like elevations appear here and there (Fig. 3) with corresponding depressions beneath them. By sucking up water these warts elongate into hollow threads, finally breaking away from the mass by contraction (Figs. 3, 4 and 5). If the film is closely adjacent to the slide no water can be sucked into the warts and the threads will be solid (Figs. 6 and 7).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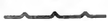
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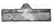
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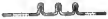
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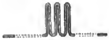
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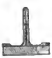
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Fig. 8.

Fig. 9.

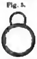
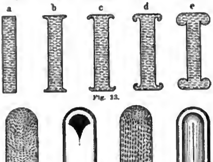


Fig. 10.

Fig. 11.

Fig. 12.



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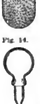
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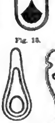
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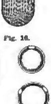
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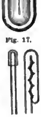
Fig. 17.

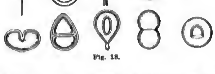
Fig. 18.

When these warts form on the surface of an air bubble the hair-like depressions at their bases are pulled apart, as the surface tension of the liquid crystaline mass is less than that of the water, and the interesting appearance shown in Figs. 8 to 12 is obtained.

All these phenomena are explainable by the expansion of the substance through swelling, in combination with mechanical anisotrophy (*anisotropie*), that is, the ability of the tablet-shaped molecules easily to glide over one another in a direction parallel to their surfaces, but not in a direction perpendicular to them. Absorption therefore causes increase in length, not in thickness. Twisting motion occurs through the uneven absorption, and by constriction division may result.

The myelin forms of para-azo-oxy-cinnamic-acid-ethyl-ester illustrate the above-described absorptive force. These assume, when a proper solvent is selected, semi-isotropic cylindrical forms, whose ends are plane surfaces. With sinking temperature these crystals absorb the solvent first at the ends, and the parallel gliding of the molecules occasions the appearances shown in Fig. 13 *a–e*. If there are conical structural disturbances at the ends (Fig. 14), then in ordinary light the appearance is that shown in Fig. 15.

If the plate-like molecules are grouped in co-axial cylinders around the axis, then the ends are formed as shown in Fig. 16, and Fig. 17 gives the appearance in natural light.

The peculiar shapes these absorptive liquid crystals assume, their elongation into long threads by the inflowing of liquid, the putting out of buds and swellings along these threads, the laminations resultant on the sucking in of smaller forms by larger (see Fig. 18), are extremely suggestive of similar phenomena seen in living organisms, and the analogy, being unique, is of the more value.

The minute study of form, structure and manifestation of energy of myelin forms promises to be of profound import to the understanding of the functions of living organisms; we are in the borderland between physics and physiology, already a realm of grand proportions.

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*Translated from *Annalen der Physik* for the SCIENTIFIC AMERICAN SUPPLEMENT.

Roads Built in 1914.—At the American Road Congress, recently held at Atlanta, it was stated that more than 18,000 miles of hard surfaced roads were built in 1914, and that the annual expenditure in this country for roads now amounts to $205,000,000 a year. It is appreciated, however, that there is great carelessness in this work, and it was pointed out that efficient management would effect a saving of at least 25 per cent, with a probable improvement in the character of the work done.

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